Technical Assistance Consultant’s Report

Project Number: 43357
October 2011

Mongolia: Ulaanbaatar Low Carbon Energy Supply Project Using a Public-Private Partnership Model (Financed by the Japan Special Fund)

Feasibility Report
(Main Report/Volume 1)

Prepared by: HJI Group Corporation in Association with MonEnergy Consult Co. Ltd.

For: Ministry of Mineral Resources and Energy, Mongolia

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Asian Development Bank
ULAANBAATAR LOW CARBON ENERGY SUPPLY PROJECT USING PUBLIC-PRIVATE PARTNERSHIP MODEL

ADB TA No. 7502-MON

FINAL REPORT VOLUME 1

HJI Group

In association with
MonEnergy Consult Co. Ltd.

May 2011
Ulaanbaatar Low Carbon Energy Supply Project Using Public-Private Partnership Model
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FINAL REPORT
VOLUME 1

Prepared for
The Asian Development Bank
and
The Mongolian Ministry of Mineral Resources and Energy

by
H&J, Inc.
in association with
MonEnergy Consult Co. Ltd.

May 2011
CURRENCY EQUIVALENTS
(As of 1 May 2011)

Currency Unit – Togrog (MNT)
1.00 MNT = $0.0008
$1.00 = 1,255 MNT

ABBREVIATIONS

ADB – Asian Development Bank
BOO – Build-Own-Operate
BOT – Build-Operate-Transfer
CDM – Clean Development Mechanism
CES – Central Energy System
CFB – Circulating Fluidized Bed
CHP – Combine Heat Power
CO – Carbon Monoxide
CO₂ – Carbon Dioxide
DNA – Designated National Authority
EA – Executing Agency
EHS – Environmental, Health and Safety
EIA – Environmental Impact assessment
EIRR – Economic Internal Rate of Return
EES – Eastern Energy System
EMP – Environmental Management Plan
EPC – Engineering, Procurement and Construction
ERA – Energy Regulatory Authority
ESP – Electrostatic Precipitator
FGD – Flue Gas Desulphurization
FIRR – Financial Internal Rate of Return
GDP – Gross Domestic Product
GHG – Greenhouse Gases
GoM – Government of Mongolia
HOB – Heat Only Boilers
HP – High Pressure
HVAC – Heating, Ventilating, and Air-Conditioning
IA – Implementing Agency
IDC – Interest During Construction
IGCC – Integrated Gasification Combined Cycle
JICA – Japan International Cooperation Agency
LA&R – Land Acquisition and Resettlement
LOE – Law on Energy
MMRE – Ministry of Mineral Resources and Energy
MOF – Ministry of Finance
MRTCUD – Ministry of Roads, Transportation, Construction and Urban Development
MNET – Ministry of Nature, Environment and Tourism
NDC – National Dispatch Center
NDIC – National Development and Innovation Committee
NOx – Nitrogen Oxides
O&M – Operation and Maintenance
PIU – Project Implementation Unit
PM – Particulate Matter
PPP – Public Private Partnership
SO₂ – Sulfur Dioxide
SPC – State Property Committee
SPS – Safeguard Policy Statement
TA – Technical Assistance
TOR – Terms of Reference
TSP – Total Suspended Particle
UB – Ulaanbaatar
UBCG – Ulaanbaatar City Government
UBDHC – UB District Heating Company
USAG – Water Supply & Sewerage Authority of UB
UWR – Underground Water Resources
WACC – Weighted Average Cost of Capital
WAM – Water Authority of Mongolia
WES – Western Energy System

WEIGHTS AND MEASURES

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
MWt – megawatt thermal energy
W (watt) – unit of active power
Cal (Calorie) – unit of energy
Gcal/hr (giga calorie/hr) – 1,000,000,000 calorie/hr
Ton – metric ton

NOTE

In this report, “$” refers to U.S. dollar.
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EXECUTIVE SUMMARY

A. Introduction and Scope of Work

1. This report presents the findings of the Asian Development Bank’s (ADB) technical assistance project, reference TA No. 7502-MON, Ulaanbaatar Low Carbon Energy Supply Project Using Public-Private Partnership Model – referred to subsequently simply as the TA. The primary objective of the TA was to support the Mongolian Ministry of Mineral Resources and Energy (MMRE) to conduct a feasibility study, incorporating a full environmental impact assessment study, for the Mongolian government (GoM) proposals to construct a new Combined Heat and Power Plant to serve Ulaanbaatar, the capital city of Mongolia. Secondary objectives were that the TA should promote (i) the use of a low carbon strategy and reduced emissions of pollutants; (ii) conservation of natural resources; (iii) energy efficiency; and (iv) the possible use of Public-Private Partnership (PPP) financing in the feasibility study report.

2. Due to the growing space heating and electricity demands from Ulaanbaatar (UB) and aging existing heat and power generation facilities, an urgent need has now arisen for the construction of new district heating and power supply infrastructure to address the growing vulnerability of heat and power supplies in the capital city. In response to this situation, the MMRE (on behalf of GoM) therefore developed outline proposals for the construction of a new combined heat and power (CHP) plant in UB, commonly known as the CHP5 plant project (the Project). These outline proposals formed the starting point for the TA work.

3. The scope of the TA included the conceptual technical design of the CHP5 plant; the identification of sector risks in constructing the CHP5 plant; the environmental impact assessment study; analysis of alternative project financing options; and dissemination of knowledge in implementing the CHP5 project.

4. The technical studies of the TA primarily focused on demands forecast; CHP plant justification; proposed plant size and technology; heat supply system analysis; site selection and surveys; coal analysis; master planning of the plant site; main equipment selection; power supply system; thermodynamic system; combustion system; water supply system; control system; civil works; heating, ventilating, and air-conditioning; pollution counter-measures; energy efficiency; water conservation and materials conservation measures; fire protection and safety; environmental impact assessment; evaluation of application of clean development mechanism; social impact assessment; public consultation; project implementation; financial analysis; and economic analysis.

5. Related sector assessments have been conducted in areas of district heating; power supply; tariff setting methodology; coal resources and supply; water resources and supply; and off-taker arrangements to identify the sector risks facing the CHP5 plant and provide recommendations including institutional arrangements, policy, or legislative measures to mitigate these risks. The comparative evaluations of different financing options have been made to identify the most appropriate approach for the project financing and to assess and provide recommendations.

B. Overall Conclusions Reached

6. The TA studies have confirmed the urgent need for the construction of new heating and power supply infrastructure and that use of modern CHP technology is preferable to independent power and heating supply projects from both a financial and environmental perspective. The strategy should therefore be to construct CHP facilities that can fully meet the UB heating demand, with any excess power demand met by importing power from outside UB (as it is more economical and with lower carbon emissions to transmit electricity...
than to transport coal).

7. Economic analysis indicates economic benefits significantly exceed economic costs with an economic internal rate of return (EIRR) estimated at 20%. Benefits from the Project include improved efficiency in power and heat production; greatly reduced emissions leading to improved air quality in UB and its surrounding areas, and with consequential health benefits; and more affordable access to heating in the areas of UB that will be newly served by district heating. In this latter aspect especially, the CHP5 project shines as a pro-poor initiative.

8. Amongst the alternative locations investigated, the TA concludes that use of the current CHP3 site represents the best location for CHP5 as this maximizes the use of existing support infrastructure. It is recommended that the low-pressure system of CHP3 plant be removed and new CHP5 plant be constructed to provide heating capacity of 1,101 Gcal/hr and electric power generation capacity of 820 MW to meet forecast demands to 2020, with construction undertaken in two phases.

9. The environmental impact assessment study has demonstrated that the CHP5 will result in positive net environmental benefits and also confirms the CHP3 site as the preferred location from an environmental perspective. With CHP5 superseding the existing CHP3, there will be significant reductions in emissions of pollutants and much improved efficiency in the use of natural resources and energy within the plant. As CHP5 will facilitate the closure or refurbishment of heat-only-boilers (HOBs) in UB areas and conversion of the old CHP2 plant as a heating only facility, there is scope for further emissions reduction and consequential air quality improvements in UB.

10. The study of alternative financing options for CHP5 concludes that whilst a PPP approach is perfectly feasible it may not be the best financing approach given the urgency of the CHP5 project, its complexity, and GoM’s inexperience in the use of large PPP. However, this conclusion assumes public financing could be arranged without undue delay, which may or may not prove possible.

11. Due to the urgent need for heat in UB and short construction season in Mongolia, the project implementation schedule to complete Phase I by 2015 is very tight. The GoM needs to make a decision on how to finance Phase I of the Project and move forward to implementing the CHP5 project as soon as possible.

12. The remainder of this Executive Summary summarizes the TA findings that support these overall conclusions. Details of TA work performed and more detailed findings can be found in the main TA report, whilst detailed analysis and supporting information are provided in the various appendices to the main TA report.

C. Heating Demand and Supply Assessment

13. Based on the assessment of the current load and heat consumption in UB, the current heat sources, as well as heat load estimations made respectively by the Energy Authority and JICA team, the TA team’s analysis suggests that an additional heating demand of 453 Gcal/hr by 2015 and 1,101 Gcal/hr by 2020 will be needed for UB.

14. In 2009, total electricity consumption of the district heating network of UB was 62.6 million kWh and the total heat supply was 4.46 million Gcal. The electricity consumption per Gcal heating supply was 14 kWh/Gcal, much higher than the international best practice of less than 7 kWh/Gcal.

15. Currently, there are two types of heating systems in UB: the district heating system managed by the UB District Heating Company, and smaller sized HOB based heating systems serving some individual buildings or complexes. The district heating system uses indirect connection, which employs heat exchange stations between the primary heating
network and the end users. The existing CHP2 and CHP4 are located on the west edge of the urban area of UB while CHP3 is located in the southern part of the central urban area. CHP2 provides heat to the north-west urban area of UB, while CHP3 covers the central urban area, and the remaining heating network is served by CHP4.

16. There are concerns over long heat transmission distance from the west or south to the east part of UB. Currently, the maximum distance between the heat source and customers reaches 16.7 km. Hence the hydraulic balance of the heating system is an ongoing challenge. Technically, the ideal site for the CHP5 would be at the eastern edge of the urban area. However, no suitable site has been identified in this area despite extensive investigation, and the location of the new CHP5 plant at the current CHP3 site is considered the best feasible solution. In order to address the concerns regarding providing reliable and adequate heating service to the eastern part of UB, hydraulic calculations were performed and the results indicated that adequate pressures can be established to ensure heating service quality through a proper engineering design of the pumping and pipeline systems. Furthermore, the hydraulic balance can be maintained through installation of effective balance valves and a modern control and monitoring system to ensure a stable and reliable heating system.

D. Power Supply and Demand Assessment

17. Totally, there are seven main coal-fired power plants in Mongolia with total installed capacity of 856.3 MW. However, due to the aged, deteriorating, and unreliable equipment, the actual available power capacity is only 615 MW. Electricity is supplied through three centralized power grids and two isolated electric systems. The Central Energy System (CES) is the biggest power generation and transmission system and the three large-sized power plants of CHP2, CHP3, and CHP4 located in UB account for 90% of the total installed CES capacity. The electricity grid of the CES consists of a large 220 kV and 110 kV transmission network.

18. A critical review of power demand forecasts based on the previous assessment completed by the National Dispatching Center and UB Municipal Governor’s Office concludes that the demand for power will increase significantly after 2014. The power supply of the CHP5 is proposed to be 450 MW by 2015 and 820 MW by 2020, which is compatible with the forecast heat demand. However, based on the power demand forecast and the power supply capacity of the existing power plants (including the proposed CHP5), an annual balance sheet for power supply indicates that as the power demand increases, the available supply cannot fully meet the demand. The excess power demand should be covered by other sources, such as constructing new power plants near coal mines and imports from other countries. By 2015, the balance that should be covered by other power sources is 158 MW when Phase I becomes operational and balance will be 93 MW by 2020 when Phase II of the CHP5 is scheduled to be completed. The balance will reach 686 MW by 2030.

E. Analysis of Alternatives and Site Selection

19. Although CHP is an efficient, clean, and economical solution to provide heat and electricity supply, other options were also considered as well to identify the most suitable alternatives with respect to the selection of technology and plant location. Three options to be evaluated in detail during the TA, which represented the views and concerns of local stakeholders, were agreed with MMRE and ADB. Option 1 was to build a new CHP plant in Ulaasai Valley on the eastern outskirts of UB. Option 2 was to build a new condensing power plant at the Baganuur coal mine to produce electricity only, while HOB plants are built in UB for heat supply. Option 3 was to build a new CHP plant at the existing CHP3 site and utilize most of its existing support infrastructure.

20. Comparative analysis using over 30 parameters -- including geological conditions; technology selection; water supply source; railway access; power transmission; energy
efficiency consideration; environmental protection; land acquisition and resettlement; construction works; total capital investment; and annual operating cost -- resulted in the following conclusions:

- **Option 1** has the advantage of balancing heat supply in UB and high energy efficiency, but a number of disadvantages count against it, including i) an active fault near the proposed site; ii) environmental concerns (too close to water wells for UB drinking water supply); iii) the land is not flat; iv) 30 hectares (ha) of land is not enough (needs 51 ha); v) no land for ash yard (needs 35 ha); vi) requires water supply from UB city; vii) requires link railway with an overpass; and viii) requires building an access road to the plant.

- **Option 2** has some advantages, including i) the power plant is far away from urban area; ii) HOB plants are near residential heat users; and iii) less transportation cost for coal. However, its disadvantages seriously compromise these apparent advantages: i) the land for the four HOB plants and ash yard needed in UB are not readily available; ii) transporting coal to these HOB plants near residential areas; iii) transporting ash; iv) construction of 220 kV transmission lines from the power plant to UB is required; v) a large land acquisition requirement; vi) Baganuur mine does not currently have enough coal production capacity; vii) low overall energy efficiency; viii) inefficient use of coal as CHP benefits are lost; and ix) a much higher initial capital cost.

- **Option 3** has a number of significant advantages as compared to the other two options, including: i) enough land for the new CHP plant; ii) existing infrastructure (railway, road, heating pipelines, etc.) can be used; iii) adequate water supply from existing wells; iv) high energy efficiency; and v) lower costs than the other two options. However, there are some limited disadvantages as well: i) the ash yard will need to be expanded or a solution found to beneficially utilize ash; ii) close proximity to UB urban area; and iii) a new main heating pipeline will be required to connect the east part of UB to supply heat to this area.

21. The comparative analysis suggests that Option 3 is the best option for the proposed new CHP plant in UB. It can modernize and revitalize the existing CHP3 plant. Most of the existing infrastructures at CHP3 can be utilized. The build-and-scrap method can be applied to build a new CHP plant while the existing CHP3 plant continues to operate until some units of the new CHP plant are operational.

22. Under Option 3 there are two sub-options, one is to remove the low-pressure system and the other is to remove both the low-pressure system and the high-pressure (HP) system of the CHP3 plant. The "with HP system retained" sub-option is selected as the core option for this main report as this option costs less and there is also a desire to keep HP by some stakeholders. The "without HP system" sub-option is also described in detail in Appendix 10.

23. Additionally, Option 3 will bring environmental benefits to UB as air emissions will be reduced and water consumption per unit of energy generation will be significantly decreased. The TA Team therefore recommends Option 3 be adopted for the location and construction of the new CHP5 plant.

**F. Conceptual Design of the New Power Plant**

24. The principle of “Power Determined by Heat” was followed in the conceptual engineering design, which has been undertaken covering all aspects of the plant. This involved twenty-five areas of investigation as detailed in the main report.

25. Based on the heating demand and power demand forecast, 5 x 150 MW steam
extracting turbines and one 70 MW back-pressure turbine are planned. Based on the detailed calculations, the maximum heating capacity of the six turbines will be 1,281 MW (1,101 Gcal/hr) and the power generation from the six turbines will be 820 MW under the maximum heating capacity. The Project should be implemented in two phases. During Phase I, 3 x 150 MW steam extracting turbines, with total 587 MW (505 Gcal/hr) heating capacity, should be installed. During Phase II, an additional 2 x 150 MW steam extracting turbines and one 70 MW back-pressure turbine should be installed, with total 1,281 MW (1,101 Gcal/hr) heating capacity for both phases. Key indicators of the CHP5 have been specified and they are shown in Section VII and Appendix 3 of the main report.

26. Upon technical analysis and considering proven international practices, a circulating fluidized-bed type of boiler is recommended for CHP5 due to the fact that it is technically mature, operationally reliable, commercially available, and economically viable. The technical specifications of boilers, steam turbines, and generators of the CHP5 are shown in Tables 7-6, 7-7, and 7-8 of Section VII of the main report.

G. Environmental Impact Assessment

27. The environmental impact assessment has been conducted in accordance with the requirements of applicable GoM environmental laws and regulations and ADB safeguards policies. Physical environmental conditions in relation to topography and geography, soil distribution, soil erosion, geology and seismic, and climate were assessed and analyzed. The environmental baseline was assessed with regard to surface water, noise, and air quality. The negative environmental impacts were identified and mitigation measures were proposed to address issues associated with air emission, liquid waste generation, solid waste generation, and noise.

28. The proposed CHP5 plant will use modern technologies that will result in lower air emissions and less water consumption. In addition, the state-of-art emission control technologies, such as electrostatic precipitators, low NOx burning devices, and additional post combustion nitrogen oxide (NOx) control have been recommended. Limestone will be injected into the furnace to control sulfur dioxide (SO\textsubscript{2}) emissions. The emissions per unit heat and electricity produced by the CHP5 plant will be much lower than the existing CHPs in UB. Due to inherent high efficiency of CHP technologies, coal consumption per unit of energy generation will also be much lower than if separate power and heating plants were to be constructed. Thus, the CHP5 project, as now proposed, will bring significant environmental benefits to UB and its surrounding areas while it is considered that the negative environmental impacts can be successfully mitigated.

H. Financial Evaluation

29. The financial analysis was carried out using ADB Guidelines and has produced as outputs the projected Financial Internal Rate of Return (FIRR) and Weighted Average Cost of Capital (WACC), results of sensitivity analysis and indicative financial statements for the CHP5 company based on certain assumptions. The total project cost is estimated to be U.S. $1.35 billion, whilst for Phase I only, it is U.S. $666 million. A number of financing scenarios were used for the sensitivity analysis, ranging from all concessionary loans to all commercial loans and a PPP mechanism including concessionary finance, commercial finance, and private equity. Analysis reveals that currently there is a cross-subsidy from the power tariff in favor of heating tariffs.

30. Under full concessionary financing where both Phase I and Phase II are undertaken, the cost reflective electricity tariff on project completion is MNT 61/kWh and the heating tariff is MNT 19,467/Gcal. Tariffs decrease in future years as debt service reduces. These are substantially higher than the CHP4 tariff of MNT 35.85/kWh and MNT 7,533/Gcal and the weighted average tariffs of CHP2, CHP3, and CHP4 of MNT 41.23/kWh and MNT 7,583/Gcal.
31. Under PPP scenarios, the FIRRs are less than WACC in most cases. In order for the Project to be financially viable (FIRR>WACC) tariffs under PPP have to be significantly increased.

I. Evaluation of Public Private Partnership

32. The TA study has considered the possible use of a PPP approach to implement the CHP5 project and identified issues that need to be considered and resolved if such an approach is to be adopted as the principal financing channel. Section X of the main report and Appendix 6 of the report provide detailed discussion and analysis.

33. Based on GoM objectives, a PPP financing option would undoubtedly be preferred to the traditional public procurement option for CHP5 if the project was to be a “green-field” one and a satisfactory means of mitigating the inherently higher PPP financing costs could be found. In this situation, a PPP procurement using the Build-Own-Operate (BOO) contract model would be favored as giving the closest fit to GoM objectives. However, the selection of the CHP3 site and the preference to retain some of the existing CHP3 facilities has significantly increased the complexity of the Project from a PPP perspective, and potentially reduced the PPP contractor’s scope to innovate.

34. Despite this, it is considered that use of PPP for CHP5 would still deliver some important benefits and PPP remains a feasible financing option. However, the urgency of the Project, its increasing complexity now that use of the CHP3 site has been selected, and the lack of PPP experience in Mongolia are major concerns that increase the risk of the PPP being unsuccessful or encountering delay.

35. After careful consideration, we believe it would reduce project risk if traditional public financing of CHP5 were to be adopted for the Phase I construction, and then PPP adopted for Phase II by transferring the Phase I assets to a PPP contractor. However, this pre-supposes that the government is able to raise the initial finance required to construct the Phase I facility.

36. If PPP was to become the preferred procurement method for CHP5 then we believe the generic BOO model should be used, although modified to take account of the Project’s particular features. In this situation, our suggestion would be that the existing CHP3 company should become a PPP joint venture company, and be the implementation vehicle for the CHP5 project.

37. The proposed phasing of CHP5 raises the issue of whether the PPP should be designed to cover both phases, or just the initial phase. The degree of interdependence between the two phases (e.g., sharing of common facilities, staff, and operating systems) suggests it would be almost impossible to segregate the facilities. Therefore, the PPP should be procured for the whole facility (i.e., both phases).

38. If PPP is adopted, then GoM can maximize the prospects for a successful PPP by taking the following steps in the PPP design that mitigate the PPP contractors’ risk in areas they may feel they lack control:

- Exclude supporting infrastructure located outside the selected CHP5 site from the scope of the PPP. This also reflects current institutional arrangements.
- Give assurances (or better still, guarantees) in respect of the minimum level of power and heat take-off from the CHP5 facility.
- The PPP contract allows for settlement in the PPP contractors’ nominated foreign currency which transfers the foreign exchange rate risk to GoM.
- GoM gives assurance over the “freedom of design” flexibility to be given to the PPP contractor (subject to the PPP contractor giving performance guarantees over output, reliability, and environmental standards).
GoM gives assurance over the availability and price of coal to be paid by the PPP contractor.

GoM gives assurance over the availability of water supply up to a certain level.

39. In addition, GoM should:

- Offer to be a joint venture partner in the PPP (but not insist).
- Facilitate CHP5 company’s access to concessionary finance.
- Expedite the establishment of a multi-disciplinary project team for CHP5 implementation and the appointment of technical advisors.

J. Economic Evaluation

40. Economic analysis performed during the TA concludes that economic benefits to the community far outweigh the economic costs of the CHP5 project. Furthermore, the economic benefits of the CHP5 project are clearly pro-poor, in that without more power and heating, wealthy residents could afford expensive but heavily-polluting substitutes not accessible to the poor. In contrast, a new clean CHP5 plant will efficiently deliver heat and power to those less able to pay, and result in a much cleaner, healthier environment.

41. Four items identified as having an economic cost greater than the current financial cost are coal, coal transport, water and land. Coal mined in comparative conditions under market forces is estimated to cost U.S. $30/ton; coal transport should be slightly higher in real cost; water is not free but was tagged at the same price paid in UB of 1,000 MNT/m³; and the land was estimated to have an opportunity cost of U.S. $500,000/ha.

42. The CHP5 project is technically proven by consumer surplus analysis. The nature of the demand curve for heat and power is clearly conventional sloping down from a high hypothetical tariff where a few would pay to the actual tariff where several hundred thousand consumers do actually pay. In a “without project” scenario, the high price of alternatives such as Russian power, and especially reversion to heating with individual coal stoves at over $1/day per household, completely negate that as a viable option. Another strong economic benefit is improved air quality estimated to be worth $10 million per year by statistically imputed avoidance of hospitalization, early death, and debilitating respiratory problems.

K. Energy Efficiency, Emissions Reduction, and Resource Conservation

43. Energy efficiency in the combined heat and power generation of 59.7% should be achieved by CHP5 which contrasts with 40.1%, 38.6%, and 21.0% in the current CHP4, CHP3, and CHP2 facilities, respectively.

44. Once operating at full capacity, the estimated annual emissions from the new CHP5 plant (excluding the HP system of CHP3) will be 150 tons of particulate matter (PM), 6,950 tons of SO₂ and 8,130 tons of NOx. This compares with total emissions from the existing three CHP plants and HOBs to be replaced of 557,000 tons of PM, 18,990 tons of SO₂ and 22,230 tons of NOx. The improvement in emissions control is best illustrated by comparing the emissions per kWh power generated. The PM emission from CHP5 is 0.04 g/kWh while the average PM emissions from CHP2 and CHP3 are 20.9 g/kWh. Similar the SO₂ and NOx emissions from CHP5 are 1.7 and 2.0 g/kWh, respectively, while average SO₂ and NOx emissions from CHP2 and CHP3 are 6.6 and 7.7 g/kWh, respectively.

45. CHP5 will consume natural resources principally in the form of coal and water. In both respects, CHP5 will be more efficient than the existing plants. Compared to CHP3, the new CHP5 will achieve significant savings in coal and water usage, respectively, per unit of power production. Specifically, the water consumptions per unit of electricity produced for
CHP3 and CHP5 are 13.9 kg/kWh and 1.98 kg/kWh, respectively. Similarly, equivalent coal consumptions per unit of electricity produced for CHP3 and CHP5 are 359 g/kWh and 263 g/kWh, respectively.

L. Beneficial Use of Coal Ash

46. A market survey study during the TA indicates that there is a increasing demand of coal ash in various construction sectors. It is estimated that the coal ash demand will be more than 1.1 million tons by 2016 when the Phase I of the CHP5 will become operational and this is far more than the estimated ash production of 0.27 million tons per annum from the CHP5 from 2016-2020 and 0.53 million tons per annum from 2021.

47. A comprehensive study on coal and coal ash radiation issue concludes that the radiation levels are below the Mongolian national standards and coal ash can be used for as a raw material for various construction materials.

M. Land Acquisition and Resettlement

48. The Project will need to permanently acquire 25,000 m² of land from seven entities and two households. Eight out of the nine affected entities/households will completely (100%) lose their land and the remaining one will lose approximately 49% of its land. Along with land acquisition, about 5,193 m² of residential and office buildings and storage houses, and 2,930 m² of temporary structures will also be affected. The affected entities have 241 employees. In addition, the construction of pipelines on public land will temporarily occupy some existing streets/roads during construction. Negotiated land acquisition and resettlement will be adopted for this Project and a resettlement framework has been prepared to guide the planning and implementation of land acquisition and resettlement.

N. Implementation Plan

49. The GoM is committed to implement the CHP5 project. In order to facilitate the implementation of the Project, a project steering committee has been established and it is chaired by the Vice Minister of MMRE with fourteen other members from various government agencies and other organizations. The Steering Committee had its first meeting on 26 April 2011.

50. The CHP5 project implementation schedule has been developed describing all major project implementation activities over a 10-year project implementation period from 2010 through 2020. The project implementation schedule covers four major project implementation stages with indicative milestones to ensure that the project is implemented within the planned timeframe: i) project preparation; ii) pre-construction; iii) procurement; and iv) construction and commissioning.

51. The construction season is relative short in Mongolia due to the long winter season. Thus, some tasks must be performed in parallel and be well-coordinated in order to meet the target of completing Phase I by 2015. The project implementation plan for both Phase I and Phase II are illustrated in Figure 13.1 of the main report.

O. Other Outstanding Issues

52. The dates for retiring CHP2 and CHP3 have not been decided yet. The TA Team understands that there is proposal to convert CH2 to a coal conversion plant. There is a desire to keep the HP system of the CHP3 plant since over $50 million have been invested in the late 1990s in the system. The retirement of these two plants will directly impact the load factor of the CHP5. Once the CHP5 plant is operational, it will be the most efficient plant in Mongolia so it makes sense to operate this plant as much as possible.
53. The GoM should reassess whether to keep the HP system of CHP3 in operation once the Phase I is put into service. The TA Team has provided a conceptual design, detailed cost estimates and financial analysis for the new CHP5 plant with the HP system removed (see Appendix 10 for details).

54. The current coal production capacities from Baganuur and Shivee-Ovoo coal mines are not sufficient to supply the new CHP5 plant. Thus feasibility studies for expanding the mining operations and increasing production should be conducted as soon as possible.

55. It has been confirmed by the Mongolian-Russian Joint Stock UB Railway that the UB-1 Station can handle the additional train traffic for coal transportation to the CHP5 plant. However, the branch railway line needs to be upgraded and an overpass will be needed to cross a busy street. A detailed feasibility study should be conducted to develop specific plans for the upgrade of the branch railway from UB-1 Station to the CHP3 site.

56. The UB district heating network is fairly large and getting more complex as the City has grown over the last decade. Energy losses are significant within the heating distribution network. UB Municipality also has a plan to expand the apartment development in many parts of the city. However, there are no specific and detailed plans to connect these new development areas to the UB district heating network. Detailed studies will be necessary to optimize the heating network so energy losses can be reduced and the quality of heating services can be ensured. This study should be done concurrently with the implementation of the Phase I of the CHP5 project.
I. INTRODUCTION

A. General

1. Mongolia has an extremely harsh winter climate, with winter temperatures ranging from -10°C to -30°C in the daytime during mid-winter (late December and January.) Further, temperatures can drop to as low as -40°C at night. The long and harsh winter weather subsequently creates an unusually long heating season, with a total of eight months from the middle of September to the middle of May.

2. Ulaanbaatar (UB) is the coldest capital city in the world and where almost half of the country’s population resides. UB residents depend on a reliable heating system to both survive and make a living. Reliable heating service is not merely a utility for residents, business entities and government organizations, it is a matter of life and death. Thus, a safe, clean, and reliable heating supply in winter months is a critical need.

3. Mongolia’s economy has experienced significant growth in the last decade and is currently rebounding strongly after experiencing a severe downturn in 2008 and 2009. The gross domestic product (GDP) growth is preliminarily estimated by the World Bank to be 6.1% year-on-year in 2010.¹ Along with the economic growth, heat and electricity demands have also grown rapidly while the supply remains relatively stable.

4. Due to the aging existing heat and power generation facilities in UB, the heat and power supply system in the capital city is quite vulnerable. There is a general consensus that it is an urgent need to build a new combined heat and power (CHP) plant to meet the increased demands of heat and power.

5. In response to a Government of Mongolia (GoM) request, the Asian Development Bank (ADB) agreed to provide a technical assistance (TA) grant to perform a feasibility and environmental impact study for the preparation of the UB Low Carbon Energy Supply Project Using Public-Private Partnership Model (the Project) which involves the construction of a proposed new CHP plant. The Project is commonly known as the “CHP5 project.”

6. The Executing Agency (EA) for the Project is the Ministry of Mineral Resources and Energy (MMRE) of Mongolia and the implementing agency (IA) is the Energy Authority, the Government Implementation Agency of MMRE. A project implementation unit (PIU) within the Energy Authority has been established to coordinate the implementation of the CHP5 project.

B. Appointment and TA Consulting Team

7. H&J, Inc., in association with MonEnergy Consult Co., was selected as the TA consultant (TA Team) by ADB through international competitive bidding process. The TA contract was signed by ADB and H&J on 13 August 2010, and in view of the urgency of the Project, the TA team quickly mobilized to UB at the end August 2010. The TA Team has comprised 27 specialists, including 12 international specialists and 15 Mongolian national specialists, working together as a team to perform the tasks specified in the TOR, and under the guidance of ADB and MMRE. The key milestones during the TA have been:

   i) Submission of Inception Report - 30th September 2010
   ii) Inception Workshop - 15th October 2010
   iii) Submission of Interim Report - 8th December 2010

¹ World Bank Mongolia Quarterly Economic Update, January 2011
iv) Interim Workshop - 17th December 2010
v) Submission of Draft Final Report - 8th March 2011
vi) Final Workshop - 17th March 2011

8. Feedback from stakeholders has been obtained in the form of written comments to the formal reports, during the project workshops and informally from the many meetings and discussions held throughout the TA. Comments received following the submission of the draft final report have been incorporated as appropriate during the preparation of this final report. Detailed responses to the main comments received are documented in Appendix 11.

C. Objective and Scope of the TA

9. The overall objective of the Project is to improve the security and reliability of energy supply for UB and Mongolia. The intended outcome of the TA is to identify and address key issues so the CHP5 project can be implemented as soon as possible. The outputs of the TA include: i) a conceptual technical design of the CHP5 plant; ii) the identification of sector risks in constructing the CHP5 plant; iii) an environmental impact assessment study report; iv) an analysis of alternative project financing options; v) an evaluation of suitability of public-private partnership model for the implementation of the CHP5 project; vi) dissemination of knowledge through workshop shops and meetings; and vii) all required reports, including appendixes in English and Mongolian.

10. The detailed scope of work of the TA as defined in the Terms of Reference (TOR) for the Consulting Services is summarized as follows:

(i) **Technical Studies**: Carrying out technical studies on the following areas: demands forecast, power plant justification, proposed plant size and technology, heat supply system analysis, site selection and surveys, coal analysis, master planning of the plant site, main equipment design, power supply system, thermodynamic system, combustion system, water supply system, control system, civil works, heating, ventilating, and air conditioning (HVAC), pollution countermeasures, energy efficiency, water conservation and materials conservation measures, fire protection and safety, environmental impact assessment, application of clean development mechanism, social impact assessment, public consultation, project implementation, financial analysis, and economic analysis.

(ii) **Sector Assessments**: Conducting assessments on the related sectors as following: district heating; power supply; tariff setting methodology; coal resource and supply; water resource and supply; and off-takers arrangements. Through the Sector Assessment, the TA consulting team (TA Team) will identify the sector risks facing the CHP5 plant and provide recommendations, including institutional changes, policy, or legislative measures to mitigate these risks.

(iii) **Comparison of Project Financing Options**: Making comparative evaluations on different financing options, identifying the most appropriate approach for the project financing, and assessing and providing recommendations such as extending certain fiscal and tax incentives to the successful bidder in order to make the CHP5 project financially attractive.

(iv) **Knowledge Dissemination**: Organizing workshops for stakeholders to get their input and communicate the features of the proposed CHP5 plant and how the UB energy supply will be made sustainable; and preparing a policy note and investment guidance in the power sector to explain the basis and process of investing in the power sector in Mongolia.
11. The TA Team performed the tasks specified in the TOR under the guidance from the ADB and MMRE. All tasks listed in the TOR and how these have been addressed by the TA Team are presented in Appendix 1.

12. As with many TA projects the work has not progressed exactly in the manner and to the timescale initially anticipated. When the TA commenced the favored approach was for CHP5 to be constructed on a greenfield site, with a potential location in the Uliastai Valley having been identified by MMRE and UB city government. It soon became apparent that this site was not favored by some key stakeholders, and also the TA team’s investigations revealed some serious drawbacks. As a consequence it was agreed with ADB and MMRE that three alternative sites for CHP5 be evaluated during the interim phase. This led to a decision by MMRE that the feasibility study should be based on CHP5 being located at the same site as the existing CHP3 and the Project therefore becoming a major rehabilitation and upgrade of the existing CHP3 facilities. It was also agreed the Project should make maximum use of existing CHP3 facilities and it was specifically requested the feasibility study should assume the retention of the HP system of the CHP3 plant. The draft final report was therefore based on this core option, which has been retained as the core option in this final report.

13. However, as a result of stakeholder feedback during and after the final workshop, MMRE have asked the TA team to conduct supplementary analysis on an alternative scenario whereby the HP system of the existing CHP3 is also replaced. This supplementary analysis is provided in Appendix 10.

D. Structure of the Final Report

14. This Final Report has been prepared in accordance with the contract between H&J and ADB and tasks specified in the TOR. This report presents the findings and recommendations of the TA Team. The report consists of 14 sections and 13 appendixes and they are summarized below.

15. Section I gives a general introduction about the Project, including the objectives and scope of the TA. Section II introduces the project background. Section III briefly summarizes the institutional arrangement for the implementation of the Project.

16. Section IV describes current heat supply situation in UB and demand forecast for heating demand while Section V presents the electrical power supply and demand in Mongolia.

17. Evaluation of different alternatives for supplying heat and power to UB is presented in Section VI and Appendix 2. Detailed evaluation and comparisons of three options are described and the least cost option has been recommended.

18. The results of the core technical feasibility study for the proposed new CHP plant is summarized in Section VII while the detailed assessment on each of the technical elements is shown Appendix 3.

19. The environmental impacts of the proposed CHP5 plant have been studied and the findings are summarized in Section VIII while the full environmental impact study is presented in Appendix 4.

20. Section IX summarizes the financial analysis including different scenarios while Appendix 5 describes the financial analysis in more detail. Assessment of applying a PPP approach to implement the CHP5 project is described in Section X while an in-depth PPP analysis is presented in Appendix 6 and a policy note on investing in the power section in
Mongolia is shown in Appendix 7.

21. The economic analysis of the proposed project is shown in Section XI. The land acquisition requirements and social issues are summarized in Section XII while the detailed analysis including a resettlement framework is presented in Appendixes 8 and 9.

22. A proposed implementation plan for the CHP5 project is described in Section XIII. The final section of the report, Section XIV, summarizes key conclusions and recommendations.
II. PROJECT BACKGROUND

A. General Information of the Project Area

23. Mongolia is a land-locked country, located in the central part of Asia between 41°35’ – 52°06’ of altitude and 87°47’ – 110°57’ of longitude. The climate of Mongolia is continental and has four distinct seasons. Mongolia has an extremely harsh winter climate with winter temperatures ranging from -10°C to -30°C in the daytime during mid-winter (late December and January). Further, temperatures can drop to as low as -40°C at night in January. The number of heating degree-days is very high, reaching up to 7,500°C day. The long and harsh winter weather subsequently creates an unusually long eight-month heating season. Reliable heating service is not merely a utility for citizens; it is a matter of life and death. A safe, clean, and reliable heating supply is a critical need for the entire population of Mongolia.

24. The population of Mongolia reached 2.7 million in 2009, with a 5% increase compared to that of 2006. Mongolia has staged an impressive recovery from the steep recession of late 2008 and early 2009. Moreover, the economic recovery is becoming broad-based. Strong demand for copper and coal from China are fuelling the recovery. Fiscal balances have improved strongly in step with mineral-related revenues. The gross domestic product (GDP) of Mongolia increased from 3.0 trillion MNT in 2006 to 3.6 trillion MNT in 2009, with a 5.7% annual average increase rate from 2006 to 2009². The real GDP growth for 2010 is estimated to be 6.1% year-on-year.³ Along with population growth and economic development, demand for both heating and power have also continually increased in Mongolia, especially in UB.

25. UB, the capital city of Mongolia, is the coldest capital city in the world. It is the political, economic, and culture center of Mongolia. Since the reform of Mongolia in the 1990s, the population of UB has grown rapidly mainly due to the migration stream into UB. The population of UB increased from 650,000 in 1998 to 1.16 million in 2010 at an annual average growth rate of 5% during the period between 1998 and 2010. The population of UB accounted over 44% of the country’s population in 2009⁴. As the economic center of Mongolia, UB has more than 70% of the total registered business entities in Mongolia and also accounts for 50-60% of the GDP of all of Mongolia. Due to development of the economy and influx of population into UB from rural areas, energy supply of UB, especially heating, is facing severe challenges.

B. Energy Supply System in Mongolia

26. Electricity is supplied through three centralized power grids and two isolated systems in Mongolia. The three centralized power grids are (i) Central Energy System (CES); (ii) Eastern Energy System (EES); and (iii) Western Energy System (WES). The two isolated systems are Dalanzhadgad CHP plant and local grid, and the grid for Zhavhan and Gobi-Altai aimags. The power plants in Mongolia include seven coal-fired power plants, two hydro power plants, some small diesel generators, and small renewable energy generators.

27. Coal-fired power plants provide the majority of power generation for Mongolia. There are seven main coal-fired power plants in Mongolia with total installed capacity of 856.3 MW, as shown in Table 2.1. The CES, the largest energy supply system in Mongolia, consists of five CHP plants, one transmission network, and four distribution networks, and supplies power to the cities of UB, Darkhan, and Erdenet, and the centers of 13 provinces. There are

² Source: Mongolia Yearbook 2009.
three CHP plants (CHP2, CHP3, and CHP4) in UB. The total installed capacity is 814 MW in the CES. Due to the aged, deteriorated, and unreliable equipment, the actual available power capacity is only 615 MW in the CES. In 2009, the peak power load in the CES reached 695 MW.

Table 2.1: Summary of Coal-Fired Power Plants in Mongolia

<table>
<thead>
<tr>
<th>No.</th>
<th>Coal-fired Power Plants</th>
<th>Capacity (MW)</th>
<th>Available (MW)</th>
<th>Share in CES (%)</th>
<th>Location</th>
<th>Year Installed</th>
<th>Efficiency (in 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CHP2</td>
<td>21.5</td>
<td>18</td>
<td>2.7%</td>
<td>UB</td>
<td>1961</td>
<td>21.0</td>
</tr>
<tr>
<td>2</td>
<td>CHP3</td>
<td>136</td>
<td>105</td>
<td>17.5%</td>
<td>UB</td>
<td>1968</td>
<td>38.6</td>
</tr>
<tr>
<td>3</td>
<td>CHP4</td>
<td>580</td>
<td>452</td>
<td>70.2%</td>
<td>UB</td>
<td>1983</td>
<td>40.1</td>
</tr>
<tr>
<td>4</td>
<td>Erdenet Plant</td>
<td>28.8</td>
<td>21</td>
<td>3.6%</td>
<td>Erdenet city</td>
<td>1987</td>
<td>40.8</td>
</tr>
<tr>
<td>5</td>
<td>Darkhan Plant</td>
<td>48</td>
<td>39</td>
<td>6%</td>
<td>Darkhan city</td>
<td>1965</td>
<td>28.5</td>
</tr>
<tr>
<td></td>
<td><strong>CES Subtotal</strong></td>
<td><strong>814.3</strong></td>
<td><strong>615</strong></td>
<td><strong>100%</strong></td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>Dornod Plant</td>
<td>36</td>
<td>--</td>
<td>--</td>
<td>Dornod aimag</td>
<td>1969</td>
<td>19.4</td>
</tr>
<tr>
<td>7</td>
<td>Umnugobi Plant</td>
<td>6</td>
<td>--</td>
<td>--</td>
<td>Umnugobi aimag</td>
<td>2001</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>856.3</strong></td>
<td>---</td>
<td>---</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>


28. The present available heating capacity of the three CHP plants in UB is 1,585 Gcal/hr, while the actual heating demand in 2009 was 1,555 Gcal/hr. In other words, there is essentially no backup heating capacity in UB. This is a very undesirable situation for the coldest capital in the world. The consequences are unimaginable should one of the aging CHP plants in UB become unavailable during the middle of winter.

29. CHP2 is over 40 years old, while CHP3 has been operating for close to 40 years. It is generally agreed by experts that most parts of the heat production systems in these two plants are nearing the end of their life. The original expected retirement periods of CHP2 and CHP3 were 2005 and 2011, respectively. However, due to the lack of new replacement heating sources, these two plants must be kept in operation.

30. CHP4 is the largest coal-fired CHP plant in Mongolia, with a design capacity of 540 MW and later modified to 580 MW. It covers 70% of total electricity demand of the CES and 64% of total heat energy demand of the district heating system of UB. The plant was built over 27 years ago and many upgrades and repairs have been made in recent years.

31. Due to various reasons including low boiler efficiencies, low steam/water cycle efficiencies, excessive consumption of heat and power, low condensate return, and high-energy (radiation, leakage, etc.) losses, the fuel utilization efficiency of the existing CHP plants is in the range of 20-40% for all stations. In comparison, a modern coal-fired CHP plant can achieve 50-80% fuel utilization efficiencies depending on the technologies and heat load profiles.

32. In addition to the CHPs, many small coal-fired heat-only boilers (HOBs) and domestic stoves are widely used in UB for space heating and domestic hot water production. According

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6 Fuel utilization efficiency is a ratio of the net energy (electricity and heat) production to the total fuel input to the boiler.
to a survey study, 89 HOB houses and 1,005 coal-fired water heaters were being used for public buildings and apartments in the ger areas of UB. HOBs typically have a capacity ranging from 250 kW to 1,000 kW and were designed to provide hot water and heating service to one or several buildings such as schools and kindergartens as their central heat location. In addition, domestic stoves are widely used in ger households. According to a World Bank survey, there were approximately 104,000 heating stoves in UB in 2008.

33. Due to the lack of efficient pollutant emission control measures, emissions of SO2, NOx, CO, and PM from UB energy generating facilities (including CHPs and HOBs) are major contributors to air pollution in UB. The CHP4 plant is equipped with electrostatic precipitators (ESP), but emission control systems for SO2, NOx, and CO are not in place. Other heat and power generators, including CHP2, CHP3, HOBs, and domestic heating stoves, do not have any emission control devices. They are the largest contributor to the bad air quality in UB during the long winter heating season. During the past few years, complaints about air pollution in the city have increased dramatically, especially during the winter months. It was reported that UB city is one of the most-polluted capital cities in the world in the winter.

1. Electricity and Heat Tariffs Setting

34. The Energy Law of Mongolia became effective in 2001 and reformed the energy sector from a centrally planned and vertically integrated structure to a new more market-oriented structure. The Energy Regulatory Authority (ERA) was established in 2001 and it is authorized to set energy tariffs in Mongolia.

35. The ERA has been following the principle of moving the tariffs close to the real-cost based tariff-pricing framework and has taken measures and steps in that direction. Tariff structures have been reformed and changed from three types of electricity and heat tariffs to the current twelve different electricity tariffs and eight different heat tariffs. The electricity and heat retail prices for consumers in the CES have increased five times since 2001. More detailed analyses of heating and electricity tariffs are presented in Section IX of this report.

36. However, due to the fact of low living standard levels and affordability issues, the Government has been providing subsidy to energy companies because it considers that it is impossible to set tariffs at the full cost recovery level. The amount of subsidy given to energy producers from the State Budget has been increasing for many years and this trend is expected to continue for the foreseeable future. For example, the amount of subsidy given to major energy producers in 2006 was 7.32 billion MNT while the subsidy amount has increased to 15.78 billion MNT in 2009. The amount of subsidy is expected to grow to 21.47 billion MNT in 2010.

2. Necessity of Additional Heating and Power Capacity

37. As mentioned previously, the existing CHP plants in the CES cannot meet the peak power load, while the available heating capacity is almost fully utilized with little backup capacity. In addition, the expected retirement period of CHP2 and CHP3 was 2005 and 2011, respectively. Even if the CHP2 and CHP3 are not decommissioned in the short term, their operation will not be stable and reliable because these plants have worked for over 30 years and their equipment is inefficient and in poor conditions. A failure or temporary outage of CHP2 or CHP3 during heating season will create serious problem to daily life of UB residents and also severely undermine the reliable energy supply in the CES.

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7 Market Study of Heat-only Boilers and Coal-fired Water Heaters in UB, 2008, MNET
8 Source: Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar, Mongolia, the World Bank, 2009.
9 World Bank, 2009, Initial Assessment of Current Situation and Effects of Abatement Measures, Air Pollution in Ulaanbaatar
38. In addition, UB’s heating and electricity demands have increased every year by approximately 6% and 5%, respectively, due to the economic development and influx of population from rural areas. Both heating and electricity demands are expected to increase in the range of 4-5% annually between 2010 and 2020. Reliable supply heat and electricity is a prerequisite to sustain economic activities in Mongolia. A draft strategy paper on the energy sector of Mongolia has been prepared and it recognized that the energy sector is essential in supporting the growing economy and sustainable development of Mongolia.11

39. As the existing CHPs and HOBs in UB are one of the major pollution emission stationary sources, replacing them with a new modern CHP plant with the best available emission control technologies is a very logical and environmentally sound choice. Therefore, it is critical to construct new energy generation facilities to serve UB and ensure the reliable supply of heat and electricity and services for the capital city whilst also improving the local environment.

40. In accordance with the energy sector development policy and the Millennium Development Goals-based Comprehensive National Development Strategy of Mongolia, during Phase I (2007-2015), a new CHP plant should be constructed in UB City. In addition, the results of the Study on City Master Plan and Urban Development of UB City financed by JICA indicated that a new power plant is required before 2015.

41. Therefore, the GoM placed the new CHP power plant (CHP5) project as one of its top priorities in the Action Plan of the Government of Mongolia for 2008–2012. The proposed capacity of the CHP plant was expected to be able to (i) meet growing energy demand resulting from rapid urbanization in UB and the city’s economic development led housing construction sectors, (ii) reduce urban air pollution by retiring CHP2 and CHP3, and (iii) improve the security of energy supply to the capital city.

3. CHP Technology

42. CHP technologies are reliable and have significantly improved in the last two decades. In its simplest form, it employs a steam turbine to drive a generator for generating electricity, and residual heat of steam after power generation is recovered, usually in a heat recovery device. The heat contained in the steam and hot water can then be used to provide industrial processing and space heating. Because CHP systems make additional use of the heat produced during electricity generation, they can achieve overall efficiencies in excess of 80%. Even for coal-fired CHP plants, the overall thermal efficiency can be as high as 50-80%. In comparison, the efficiency of a conventional coal-fired power plant, which discharges a significant amount of heat to the atmosphere, is typically about 30-40%.

43. Many countries have established policies to encourage the use of CHP when there are demands of heat and power at the same time. For example, in order to further promote CHP technologies and increase the energy efficiency and improve the security of supply of energy, the European Union issued a directive in early 2004. It states that the promotion of high-efficiency CHP based on useful heat demand is a priority given the potential benefits of CHP with regard to saving primary energy, avoiding network losses and reducing emission, in particular of GHG.12

44. The high level of efficiency achieved for CHPs has important environmental benefits, more specifically in terms of the reduction of greenhouse gases (GHGs). The levels of carbon dioxide (CO₂), NOx and SO₂ emitted from CHP plant are much less than those from a conventional coal-fired power station and HOBs. The CHP technology can provide the benefit

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of energy efficiency improvement and emissions reductions. The use of a CHP is highly advantageous in UB due to the eight-month long heating season with a stable heating load and domestic hot water demand. Therefore, CHP is a logically preferred choice to meet the heat and power demands of UB.

C. Major Activities Conducted by the Mongolian Government

45. In order to promote the implementation of the CHP5 project, the Mongolian Government has carried out a series of activities. On 7 May 2008, the Government committed MMRE to be responsible for organizing an international open tendering for the construction of the CHP5. Concerned government authorities actively worked together to complete preliminary preparation for the tendering. On 4 June 2008, the UB Municipal Government issued the land use permission for CHP5 of a 30 ha site on the east outskirt of UB at the Uliastai Valley in the ger area of Khoroo 23, Byanzurkh Duureg.

46. The Government initially wanted the private sector to construct a CHP plant. It invited bids through international competitive bidding from potential project developers worldwide. The bidders were required to propose preliminary designs of the CHP plant and financing plans. Over 20 potential investors purchased the bidding documents. However, only one qualified technical proposal was submitted before the deadline of 15 January 2009. On 20 May 2009, the Government made the final decision and announced that the tender had failed.

47. There are many reasons for the failure of the attempted private sector procurement of CHP5. One of the main reasons was inadequate preparation of the Project and a lack of information made available to potential bidders about some critical components. Another lesson learned was that the private sector will not take all the risks without adequate assurance on energy demands and reasonable tariffs for electricity and heat. ADB policy dialogue with the Government therefore identified the need to assess the suitability for Public-Private Partnership (PPP) model for CHP5 project. Risk identification, mitigation and sharing are key issues in determining in how to best proceed with major projects like the CHP5 plant. A more detailed evaluation and assessment on PPP financing model is presented in Section X and Appendix 6.

48. With the lessons learned from the failed private sector procurement, the concerned Mongolian authorities started to consolidate the preliminary preparation for the CHP5 Project. A special working group was established to finalize all investigations and studies for the implementation of the CHP5. The working group conducted assessments of potential sites, water sources and environmental issues. The major concerns are the site selection and water resource availability. The Ministry of Nature, Environment and Tourism (MNET), the Water Authority and other Agencies expressed their reservations on the site selection in Uliastai area which is located close to one of the main drinking water sources for UB. In addition, they suggested that the availability of water resources for the CHP5 should be assessed in detail, due to the serious shortage of water resources in UB and surrounding areas.
III. INSTITUTIONAL ARRANGEMENTS

49. The Project will be implemented based on the relevant laws and regulations of Mongolia and in accordance with decisions made by the GoM, authorized government agencies, and regulatory authorities.

50. Mongolia has a constitution that allows for multi-party political participation in the national parliament with the majority party normally forming the government. However, at the present time, no single political party commands a majority, and therefore a coalition government has been formed. The Constitution requires that elections are held every four years to the national parliament and the government is formed by the party (or parties) commanding a majority of seats in the parliament. Thus the Government is accountable to the Parliament. The next such elections are scheduled to be held in June 2012.

51. The Country has three tiers of elected local government which comprises (i) provinces (aimags), (ii) counties (soums) in rural areas, or districts in urban areas; and (iii) village settlements in rural areas (bags) and urban communities (khoros). In each case there is an appointed governor and an elected council of people’s representatives (a khural).

52. Special arrangements apply for governing UB which, as the capital city, is the home to approximately 40% of all Mongolians and has expanded geographically to subsume all or part of some surrounding aimags/soums. An elected UB city government headed by the city governor is directly accountable to the Government of Mongolia.

A. Legal Structure

53. Mongolia has a written constitution dating from 1992 (with minor changes made in 2000) that designates the Parliament (State Grand Khural) as the supreme decision making body, provides for the holding of elections of the parliament and the president, provides for an independent judiciary and a separate independent constitutional court, and defines the structure of local government and the appointment of local governors.

54. All laws of Mongolia must be approved by the parliament before becoming effective and it is normal for all laws to (i) specify the roles and responsibilities of the Government; (ii) identify the government office (Ministry) authorized to administer the law (“the authorized ministry”); (iii) define the duties and powers of the authorized ministry and local governments under the specific law; (iv) provide for the establishment and operation of any new government or independent agency required to administer any part(s) of the law; and (v) define the duties and powers of that agency.

55. As an example, the Law on Energy (LOE) assigns the Ministry of Mineral Resources and Energy as the authorized ministry to administer the law, provides for the establishment of the Energy Regulatory Authority and defines the duties and powers of the MMRE, the ERA and local governments relating to the LOE.

56. It is common for the individual laws to confer the right on the authorized ministry to issue relevant regulations provided for in the law. Such regulations are thus issued under the ultimate approval of the parliament.

57. For the purpose of the design and implementation of the Project the main laws relevant, or potentially relevant, are:

(i) The Law on Energy

(ii) The Law on the Environment

(iii) The Law on Environmental Impact Assessments
(iv) The Law on Land
(v) Law on Land Payment
(vi) Law on Payment for the Use of Water and Mineral Resources
(vii) The Law on Foreign Investment (if PPP by international bidding is adopted)
(viii) The Law on Concessions (if PPP is adopted)
(ix) The Law on Public Procurement
(x) The Law on Anti-corruption
(xi) The Law on Water

58. The requirements and constraints imposed by individual laws will be referred to in the relevant sections of this report prepared by the TA Team.

B. Government Administrative Structure

59. The Government of Mongolia is headed by the Prime Minister who presides over a Cabinet that comprises the Ministers, each responsible for an individual ministry. The key ministries and other government agencies likely to be involved in the Project are as presented in Figure 3.1 and their responsibilities are as follows:

60. **The Ministry of Mineral Resources and Energy.** MMRE is designated as the lead Ministry for promoting the CHP5 project and is the designated project executing agency for this TA study. Some of the responsibilities of MMRE include energy policy, energy strategy, power generation, power transmission, district heating, etc. The Energy Authority (EA), a government agency under MMRE, is responsible for overseeing the operation of the energy sector in accordance with the government’s energy policy. The EA is the project implementing agency for the TA project.

61. **The Ministry of Finance (MOF).** MOF is responsible for the preparation and administration of the State Budget. MOF is also the counterpart agency for ADB and other multi-lateral and bi-lateral aid agencies and thus coordinates foreign aid. All foreign borrowing by Government or government agencies/SOEs needs clearance from MOF who will provide required sovereign guarantees.

62. **The State Property Committee (SPC).** SPC is a Ministry level coordinating government committee, directly answerable to the Prime Minister, and is responsible for the oversight of all State owned property (Land and other assets). The Law on Concessions assigns certain administrative responsibilities to SPC in the planning, procurement and approval of Concessions contracts as defined under the Law, which would include any form of PPP. In order to discharge this responsibility, a newly created PPP unit under SPC has been formed but is not yet fully functioning. SPC also has a separate unit which is responsible for administering the Government’s privatization program.

63. **The Ministry of Nature, Environment and Tourism.** MNET is responsible for environmental protection in accordance with the Law on the Environment, and is the main administrative authority for the Law on Environmental Impact Assessments. The CHP5 project will require an environmental impact assessment, and as such, MNET is a key project stakeholder.

64. **The Ministry of Roads, Transportation, Construction and Urban Development (MRTCUD).** MRTCUD is responsible for transportation (including road, railway and aviation), construction and urban development sector in Mongolia. It will play a key role during the implementation of the CHP5 project and will also review and approve the designs before construction can start.
65. **The Energy Regulatory Authority of Mongolia (ERA).** ERA is an independent regulatory authority that was established by the 2001 Energy Law. The ERA regulates energy tariffs, grants licenses to power companies involved in the generation, transmission and distribution of electrical power, monitors compliance with license conditions, and resolves disputes between agencies and customers. The ERA is directly accountable to the Government (as represented by the Cabinet).

66. **The Water Authority of Mongolia (WAM).** WAM is an agency of the MNET with responsibilities that include water resource planning and the licensing of water abstractions. WAM approval will therefore be needed for the water supply arrangements for the new CHP5 plant (wherever this is located).

67. **The National Development and Innovation Committee (NDIC).** NDIC, like SPC, is a Ministry level government committee, directly answerable to the Prime Minister. It is responsible for economic and development planning, oversees foreign investment into the country and is a sponsor of innovation and reform initiatives on behalf of the Government. NDIC are expected to review and comment on all proposed PPP and privatization initiatives before these are endorsed by the Government, and to play an active role in the PPP process.

68. **The Municipality of UB (UBCG).** UBCG is the second tier government responsible for governing UB city and therefore responsible for the provision of all municipal services and related infrastructure in the city. UBCG is directly accountable to the national Government, and has significant autonomy on how local services are provided. UBCG is a key stakeholder in the CHP5 project and will need to make land available for the CHP5 plant and cooperate in the provision of supporting infrastructure (e.g. rail and road access). UBCG is the main potential customer for heat energy supplied by the CHP5. Important stakeholders at city level are the City Planning Department, the Water and Environmental Department, the Ulaanbaatar Water and Sewerage Authority, local district heating companies and housing management agencies (who will both be bulk purchasers of heat energy from CHP5).

**Figure 3.1: Institutional Arrangements**
C. The Power and Heating Markets

69. The Energy Regulatory Authority (ERA). The ERA was established under the 2001 Mongolian Law on Energy. Its responsibilities are to regulate generation, transmission, distribution, dispatching and supply of energy as defined in the Energy law. Its specific powers are set out in article 9 of the Energy Law and include:

- To issue, amend, suspend and revoke licenses in accordance with this law;
- To set operational and licensing terms and requirements for licensees; to monitor compliance with these terms and requirements;
- To develop methodology to determine tariffs, define the structure of tariffs; to review, approve, inspect and publish tariffs of licensees;
- To establish a pricing and tariff system that enables supply of energy at the lowest possible cost and allows an adequate rate of return; and
- To resolve disputes between licensees and disputes between licensees and consumers in accordance with its jurisdiction.

70. The Power Market. The power market currently operates as a single buyer market. The main power generators are CHP2, CHP3 & CHP4 who supply electrical energy to the Central Electricity Transmission Grid Co (CETG), which manages and maintains the national grid. The CETG then makes electricity available to the Electricity Distribution Network Companies serving different parts of the country. In Ulaanbaatar there is one single distribution company, the Ulaanbaatar Electricity Distribution Network Company (UBEDN), which in turn supplies individual customers.

71. Energy production planning, operational rules and decisions are taken by the separate National Energy Dispatch Company (NEDC), also established under the 2001 law on Energy, which determines how the CETG needs should be supplied and how available power should be shared out if there is a shortfall.

72. All market participants are licensed by the ERA which was a one off exercise that took place on the establishment of the market, with new licenses issued as appropriate to allow new entrants to enter the market. At the same time as the license were issued the ERA established a set of business rules under which the licensees must operate, and which must be incorporated as relevant into the relevant power purchase agreements (PPA). The ERA keeps these business rules under review and amends them from time to time.

73. Power Purchase Agreements (PPA) are entered into between the power generators and the CETG and Power Sales Agreements (PSA) between the CETG and the EDNs. These PPA are renewed on an annual basis, although the extent of annual changes is a matter that requires further investigation. The PPA prices are set by the ERA as part of its regulatory role.

74. Funds Flow Mechanism in the Power Market. The UBEDN bills all its customers and collects all revenues. The tariff revenues are deposited in a special bank account under CETG control and then all funds are distributed in accordance with pre-determined allocation percentages to the bank accounts of each of the market participants (the generators, CETG, NEDC, and the EDNs). This distribution takes place on a daily basis thus clearing the special bank account to a zero balance.

75. The ERA determines the allocation percentage entitlements of the different market participants and monitors the cash flows to each participant. The actual cash flows are compared with the entitlements of the market participants under the different PPA and surpluses and deficits identified. The percentage allocation is then reviewed on a quarterly basis with a view to removing surpluses/deficits (or in practise to equalise deficits).
76. In the funds allocation process preferential treatment is given to fully funding the PPA of the private EDN and also the energy imports from Russia. The Government provides subsidy in accordance with the State budget to cover all or part of the deficits of the SOEs.

77. Figure 3.2 below identifies the market participants currently relevant to providing power to the capital city and shows both the flow of power supplies and cash.

78. However, all the market participants in the UB area are national level State owned enterprises with an ownership structure as follows:

- Ministry of Mineral Resources and Energy (MMRE) - 41%
- State Property Commission (SPC) - 39%
- Ministry of Finance (MOF) - 20%

79. Because of this common ownership structure for all the main market participants we understand the market does not operate strictly in accordance with the terms of the individual PPA between the entities. Thus income shortfalls and subsidies made available by the government are currently shared.

80. As stated, the power market currently operates as a single buyer market - however we understand that reforms to create a multi-buyer market have been studied and proposals presented. We understand it is quite possible such reforms may be implemented in the foreseeable future and these reforms, and their possible impact on the PPP contractor together with the current practice of annual PPA, therefore create uncertainties that could easily cause a concern to potential PPP bidders.

81. The Heat Energy Market. Steam/Hot water for district heating and hot water supplies are provided by the CHP2, CHP3 and CHP4 plants to the Ulaanbaatar Central Heating Company (UBCHC) under a heat purchase agreement.
82. The UBCHC is a wholesaler that sells heat and hot water (the terms of which are in a heat purchase agreement) to municipal housing management companies (MHMC) that own/manage housing stock in the different parts of UB city. In all there are more than 20 of these housing companies in UB. The MHMC are heat and hot water retailers providing a heat and/or hot water service to individual apartments, commercial buildings and industries. Each MHMC is responsible for collecting heating & hot water charges and for paying for the bulk supplies it receives from UBCHC under its heat purchase agreement.

83. As for the electrical energy market the ERA regulate market operations and performance. Figure 3.3 below depicts the market operation in diagrammatic form.

84. UBCHC is a national level SOE with ownership vested in MMRE (41%), SPC (39%) and MOF (20%). The MHMCs are also all SOEs, but under local government ownership (presumed to be Ulaanbaatar city government, but some could be owned by lower levels of government).

Figure 3.3: The Ulaanbaatar Heat and Hot Water Market

Source: TA Team.
IV. HEATING DEMAND AND SUPPLY ASSESSMENT

A. Heat Demand

1. Current Heat Load and Heat Consumption

85. Heat consumers in UB are classified under three categories: industries, residential apartments, and institutions. There are three major heating modes in UB: district heating, HOBs, and domestic stoves. In 2009, the district heating system served most of the urban areas and industries in UB with total heat load of 1,555 Gcal/hr. The three combined heat and power plants of CHP2, CHP3, and CHP4 are the main heating sources. HOBs were installed to provide heat for some agencies and business organizations in the ger districts or in areas that are not currently connected to the district heating system. The total heat load of UB is now estimated at 1,602 Gcal/hr.

86. The total heat consumption of the district heating system is estimated at 3.43 million Gcal in 2009. Detailed breakdowns are shown in Table 4.1. The breakdowns indicate that the households and industrial users are the two largest heat consumers, each sharing nearly 30% of the total heat consumption. Hot water usage by households accounted for 13% of the total heat consumption, while hot water usage by organizations and process purposes each accounted for over 7% of the total heat consumption.

Table 4.1: 2009 Heat Consumption by End Users in UB

<table>
<thead>
<tr>
<th>No.</th>
<th>Consumer Classifications</th>
<th>Heat Consumption</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Industrial users and enterprises with heat meter</td>
<td>1,021,527</td>
<td>29.8%</td>
</tr>
<tr>
<td>2</td>
<td>Heating for households - residential apartments</td>
<td>995,191</td>
<td>29.0%</td>
</tr>
<tr>
<td>3</td>
<td>Hot water use of household consumers</td>
<td>453,096</td>
<td>13.2%</td>
</tr>
<tr>
<td>4</td>
<td>Process hot water use</td>
<td>274,940</td>
<td>8.0%</td>
</tr>
<tr>
<td>5</td>
<td>Apartment with heat meter</td>
<td>249,655</td>
<td>7.3%</td>
</tr>
<tr>
<td>6</td>
<td>Organizations</td>
<td>246,077</td>
<td>7.2%</td>
</tr>
<tr>
<td>7</td>
<td>Others</td>
<td>188,857</td>
<td>5.5%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,429,344</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: ERA, MMRE, Mongolia

2. Heat Load Estimations

**Heat Load Estimation by Energy Authority**

87. It is estimated by the Energy Authority that an additional heat load will reach 242.3 GCal/hr by 2012 and over 1,000 Gcal/hr by 2020. Total heat load will reach 2,176.3 Gcal/hr by 2015. However the total heating capacity in UB is only 1,585 Gcal/hr, which then leaves a demand and supply gap of 591 Gcal/hr. The gap will increase to 970 Gcal/hr by 2020. Figure 4.1 illustrates the increasing heat demand in the past 10 years as well as projections for the next 10 years.
The heat load estimation made by the JICA team suggests that additional heat load will reach 287 Gcal/hr by 2010, 744 Gcal/hr by 2015, and 1,178 Gcal/hr by 2020. The total heat capacity was 246.3 Gcal/hr in 2007, which then leaves a demand and supply gap of about 30 Gcal/hr to make up the additional heat demand of 2010. The gaps are expected to increase at 496 Gcal/hr by 2015, 932 Gcal/hr by 2020, and 1,733 Gcal/hr by 2030. Figure 4.2 presents the estimation results.

89. On average, both estimations suggest an increased heat capacity of over 450 Gcal/hr by 2015 and over 900 Gcal/hr by 2020, to make-up the load-capacity gaps.

Based on information collected by the TA Team and the UB City Master Plan, we estimated that additional heat demand will reach 343 Gcal/hr by 2015, 991 Gcal/hr by 2020,
and 1,545 Gcal/hr by 2030. Upon construction of CHP5, the CHP3 are expected to be phased out, in particular, the low pressure system which will free up to additional heat load of 110 Gcal/hr. The total heating capacity by 2015 is therefore estimated to be 453 Gcal/hr. Due to the fact that the CHP3 HP system has been reconstructed in recent years, it is feasible to keep this system. Table 4.2 provides detailed heat demand estimations during 2015, 2020 and 2030.

Table 4.2: Summary of Heat Demand Estimations

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retirement of Heat Capacity</td>
<td>Gcal/hr</td>
<td>110</td>
<td>110</td>
<td>485</td>
</tr>
<tr>
<td>Additional Heat Demand</td>
<td>Gcal/hr</td>
<td>343</td>
<td>991</td>
<td>1,545</td>
</tr>
<tr>
<td>Total Heat Demand</td>
<td>Gcal/hr</td>
<td>453</td>
<td>1,101</td>
<td>2,030</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

91. International practices suggest that it is not technically justified to design the CHP5 to meet such a huge heat demand of 2,030 Gcal/hr by 2030, due to difficulties to manage the associated heat transmission and distribution system, as well as potential financial risks as a result of heat demand fluctuation projected for 2030. The CHP5 will therefore be sized to meet the estimated heat demand of 2020. To be technically and practically feasible, the CHP5 is to be constructed in two phases. The heating capacity of the CHP5 is therefore designed at 453 Gcal/hr by 2015 and 1,101 Gcal/hr by 2020.

3. Heat Demand Curves

92. Based on the above heating demand analysis, a heat demand curve against time is developed, as shown in Figure 4.3.

Figure 4.3: Heat Demand Curve against Time

Source: TA Team estimates.
B. Heat Sources

1. Combined Heat and Power Plants

The heat sources of the district heating system in UB are CHP2, CHP3, and CHP4. These combined heat and power plants have been operating for over 25-47 years. There are 25 boilers with total thermal capacity of 5,570 ton/hr. Currently, the available thermal capacity for heating is 1,585 Gcal/hr. CHP4 is the biggest coal-fired CHP plant in Mongolia. The available heating capacity of CHP4 is 1,045 Gcal/hr. It covers 64.3% of the total heat demand of district heating system in UB. The thermal efficiency of CHP4 was estimated at 40.1% in 2009. The coal equivalent consumption rate for heat generation of CHP4 is 173.6 kg/Gcal, over 8% higher than the average international level of 160 kg/Gcal. Detailed heating capacities and heat loads for the three CHP plants are summarized in Table 4.3.

<table>
<thead>
<tr>
<th>№</th>
<th>Source</th>
<th>Available Heat Capacity (Gcal/hr)</th>
<th>Heat Load in 2009 (Gcal/hr)</th>
<th>Remaining Capacity (Gcal/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CHP No.2</td>
<td>55</td>
<td>54</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>CHP No.3</td>
<td>485</td>
<td>485</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>CHP No.4</td>
<td>1,045</td>
<td>1,016</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,585</td>
<td>1,555</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: Energy Authority, MMRE, Mongolia

2. Heat-only-Boilers and Domestic Stoves

In addition to the CHPs, there are 89 HOB houses in UB with total thermal capacity of 140 Gcal/hr. During the 2007-2008 heating period, total heat load covered by the HOBs was 47.35 Gcal/hr and total energy consumption was 123,212 Gcal. The thermal efficiencies of these HOBs are between 50% and 60%. In addition, 1,005 coal-fired water heaters with total capacity of 18.6 Gcal/hr were in operation. The total coal consumption of the heaters reached 19,857 tons in 2008. Additionally, there were about 103,971 heating stoves used to heat the gers or houses. Ger area heating systems burn continuously during the winter season and their contribution to the overall air pollution levels reaches 70% and more in the ger areas and up to 60% in the city center.13

C. Heating System

There are two types of heating systems in UB: district heating system managed by the UB District Heating Company and smaller sized HOB-based heating system. The UB district heating system uses indirect method and direct method. Indirect system employs heat exchange stations between the heat source and the customers, which has two closed loops, a primary loop and a secondary loop. Both loops work independently of each other without direct interference. In this system, the working temperatures of supply and return water of the primary heating network is 135°C and 70°C, respectively. The working temperatures of supply and return water of the secondary heating network is 90°C and 65°C, respectively. Direct system employs injector to mix return water and feed water to obtain desirable feed water temperature for end-user. Heating coverage of the existing CHPs in UB is illustrated in Figure 4.4.

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13 MONET, 2009, Market Study of Heat-only Boilers and Coal-fired Water Heaters
96. The existing CHP2 and CHP4 are located on the west edge of the urban area, and CHP3 is located in south part of the middle urban area. CHP2 covers the north-west urban area of UB as circled by the small ellipse in Figure 4.4 while CHP3 covers the middle urban area as circled by the big ellipse in Figure 4.4, and the remaining network is connected with CHP4. There are concerns over long heat transmission distance from west to east. Currently, the maximum distance between the heat source and customers reaches 25 km. Hence the hydraulic balance of the heating system is a challenge.

97. Technically, the ideal site for the CHP5 is at the east edge of the urban area. Under this scheme, the existing CHPs are to be disconnected with the existing heating system in the east and connected to the heating systems in the northern and western new development areas. The CHP5 and CHP3 HP system will cover the eastern area and will therefore supply heat for the eastern area of UB, as shown in the Figure 4.5. The proposed scheme will decrease the distance between the heat source and customers, improve the hydraulic balance performance, and reduce the power consumption of the circulating pumps and/or relay pumps.

Figure 4.4: Heating Coverage of Existing CHPs

Note: Other than areas circled by the two ellipses, the remaining areas are covered by CHP4
Source: District Heating Company of UB and TA Team.

Figure 4.5: Expected Coverage of the CHPs

Source: TA Team and District Heating Company of UB
98. There are eight booster pump stations (BPS) in the district heating network in UB. Electricity consumption of these BPSs was approximately 15.0 million kWh in 2009. Annual electricity consumption for the circulation pumps and water supply pumps was 47.6 million kWh in 2009. Total electricity consumption of the district heating network of UB is 62.6 million kWh. In 2009, the total heat supply was 4.46 million Gcal. The electricity consumption per Gcal heating supply is 14 kWh/Gcal, which is much higher than the international level of less than 7 kWh/Gcal. For the first nine months of 2010, the electricity consumption reached 29.7 million kWh. Details of electricity consumption and water leakage are provided in Appendix 3.

99. The existing heating system suffered serious water and heat losses as a result of degenerated pipeline system, and poor insulation. In order to achieve technical and economical improvement in the heating supply system of the city, it is required to take effective measures to prevent water losses, to install variable frequency pumps at the CHPs, and to improve the insulation of network with the pre-insulation polyurethane foam (PUR).
V. POWER SUPPLY ASSESSMENT

A. Power Plants in Mongolia

100. There are seven main coal-fired power plants in Mongolia with total installed capacity of 856.3 MW. The CES, with 95% of share in the total installed capacity is the largest energy supply system in Mongolia. Total installed capacity of the CES is 814 MW. Due to aged, deteriorated, and unreliable equipment, the actual available power capacity is only 615 MW. Three relative large sized power plants, including CHP2, CHP3 and CHP4 located in UB, account for 90% of total installed capacity in the CES. In addition, Erdenet Plant and Darkhan Plant with total 60 MW installed capacity has 10% of share in the total installed capacity in CES. The typical performance indicators of the three CHPs in 2009 are shown in Table 5.1.

Table 5.1: Typical Performance Indicators of the CHPs in UB (2009)

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>Units</th>
<th>CHP2</th>
<th>CHP3</th>
<th>CHP4</th>
<th>CES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Power Generation</td>
<td>Million kWh/a</td>
<td>120</td>
<td>655</td>
<td>2,711</td>
<td>3,876</td>
</tr>
<tr>
<td>Total Power Net generation</td>
<td>Million kWh/a</td>
<td>100</td>
<td>520</td>
<td>2,329</td>
<td>3,259</td>
</tr>
<tr>
<td>Internal Consumption</td>
<td>%</td>
<td>16</td>
<td>21</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Specific equivalent fuel consumption</td>
<td>Gram/kWh</td>
<td>610</td>
<td>359</td>
<td>307</td>
<td>--</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>21</td>
<td>39</td>
<td>40</td>
<td>--</td>
</tr>
</tbody>
</table>

Source: Energy Statistics Yearbook, ERA, Mongolia, 2009

B. Power Supply

101. Electricity is supplied through three centralized power grids and two isolated systems, including CES, EES, WES, Dalanzhadgad system, and Zhavhan and Gobi-Altai aimags system. The CES covers 14 aimags, the EES provides power to Sukhbaatar Aimag and the WES supplies power to the western three aimags. Seven coal-fired power plants, two small hydro power plants, numerous diesel generators, and small renewable energy generators form the structure of power sources.14

102. The CES is the biggest power generation and transmission system in which there are five electricity generation companies, one transmission company, and four distribution companies. The electricity grid of the CES consists of a large 220 kV and 110 kV transmission network. It comprises 6 substations at 220 kV and 54 at 110 kV. The largest 220 kV substation has transformation capacity of 2 x 125 MVA, and the transformation capacity of thirteen 110 kV substations located in UB area varies from 2 x 6.3 MVA to 2 x 25 MVA. The primary distribution system in UB is mainly at 35 kV that covers 208 substations.

103. A 220 kV ring system interconnects the principal generation and load centers of UB, Darkhan and Erdenet, and there are an additional 220 kV interconnections with load centers of Baganuur and Choir. The CES 220 kV grid is connected to the Russian system by a 220 kV double circuit line (about 300 MW total transmission capacity) with the connection point at the substation in Selendum, near the Russian Gusinozersk power plant. The total length of the 220 kV transmission network is about 1,705 route km, of which 911 km are double circuit lines and 794 km single circuit lines.

104. The CES transmission system further comprises a fairly large 110 kV grid connecting the main system substation and load centers. Total length of the existing 110 kV network is around 3,465 route km. The total installed transformer capacity (excluding the generator

14 Energy Regulatory Authority of Mongolia, 2010, Framework for Setting Energy Tariffs and Prices in Mongolia.
transformers) amounts to nearly 2,200 MVA. Transmission voltages are 220 kV (in the CES only) and 110 kV, while principal medium distribution voltage is 35 kV, which is further stepped down to 10 kV or 6 kV.

C. Power Demand

1. Power Demand Forecast by National Dispatching Center

105. The National Dispatching Center (NDC) is the official government organization responsible for making power demand forecasting. NDC provides such forecast based on information it collects and assumptions made. However NDC’s forecasts are quite different from the actual demands for 2008 and 2009. For example, in 2008 the actual demand was at the average scenario of the forecasted 2015 level, which means the forecast is about six years behind of real demand growth.

2. Power Demand Forecast by Municipal Governor’s Office

106. The UB Municipal Governor’s Office prepared the power demand forecast for UB area based on the analysis made on UB development plans. By 2020, potential power demand will primarily come from: (i) new apartment buildings; (ii) ger areas remaining until 2020; (iii) ger areas being replaced by new apartment buildings; and (iv) apartment buildings to be built in the city’s reserved areas. The power demand forecast in UB is shown in Figure 5.1.

Figure 5.1: Additional Power Demands for UB City up to 2020 (MW)

Source: UB Municipal Governor Office

3. Power Demand Forecast by TA Team

107. The TA team made the power demand forecast for CES using an integrated econometric and end-use approach, which allows integration of physical and behavioral factors in a common framework. While the econometric relationships would internalize the influence of economic and policy effects, the end-use approach provides an accounting plane for aggregating end-use and sector energy demands projected into the future. In addition, the Gobi mining area is planned to be interconnected to the CES in 2015 and it is included in the demand growth forecast as shown in Figure 5.2.
Due to the fact that CHP5 is mainly designed to meet the heating demand as mentioned previously, it will not fully meet the additional power demand of the CES system. In accordance with the reasonable ratio between heat generation and power generation, the power supply of the CHP5 is proposed to be 450 MW by 2015, and 820 MW by 2020. The detailed size of the CHP5 is presented in Section VI of this report. Based on the power demand forecast above and the power supply capacity of the existing power plants, the balance sheet for power supply and demand by 2030 is shown in Table 5.2. As the power demand increases, the existing power plants and new CHP5 cannot fully meet the power demand. The difference should be covered by other power sources, such as constructing new power plants near coal mines or import from other countries. By 2015, the balance that should be covered by other power sources is 158 MW, and it will be 93 MW by 2020 when the first phase of CHP5 is operational. By 2030, the balance is estimated to be 686 MW.

D. Power Transmission System

In general, the existing power transmission system has some reserves to supply the growing demand in UB. However, it will be required to reinforce the existing 110 kV ring line around UB by 2015. The distribution system already faced problems of the overloading of distribution assets. Continuous reinforcements and construction of new substations are required for the distribution system during the next 10 years.
Table 5.2: Balance Sheet of Power Supply and Demand by 2030

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<tr>
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<td>CHP-3 (MW)</td>
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<td>120</td>
<td>120</td>
<td>80</td>
<td>80</td>
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<td>CHP-4 (MW)</td>
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<td>Erdenet CHP (MW)</td>
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<tr>
<td>Total generation (MW)</td>
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<td>695</td>
<td>715</td>
<td>705</td>
<td>665</td>
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<td><strong>Original CES Demand (MW)</strong></td>
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<tr>
<td>Original CES Demand (MW)</td>
<td>762</td>
<td>819</td>
<td>862</td>
<td>934</td>
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<td>1,074</td>
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<td>1,214</td>
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<tr>
<td>Import/Other sources (MW)</td>
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<td>124</td>
<td>147</td>
<td>229</td>
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<td>-41</td>
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<tr>
<td>Ukhaahudag CHP (MW)</td>
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<td>36</td>
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<td>40</td>
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<tr>
<td>Import/Other sources (MW)</td>
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<td>128</td>
<td>181</td>
<td>196</td>
<td>270</td>
<td>280</td>
<td>302</td>
<td>290</td>
<td>235</td>
<td>202</td>
<td>219</td>
<td>238</td>
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<td><strong>Gobi area demand (MW)</strong></td>
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<tr>
<td>Total generation of existing power plant of CES (MW)</td>
<td>695</td>
<td>695</td>
<td>715</td>
<td>705</td>
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<td>CHP-5 (MW)</td>
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<tr>
<td>Total Balance of CES (MW)</td>
<td>67</td>
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<td>147</td>
<td>229</td>
<td>158</td>
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<td>389</td>
<td>410</td>
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<td>395</td>
<td>686</td>
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<tr>
<td>Total demand of CES (MW)</td>
<td>762</td>
<td>819</td>
<td>862</td>
<td>934</td>
<td>1,313</td>
<td>1,394</td>
<td>1,483</td>
<td>1,544</td>
<td>1,625</td>
<td>1,728</td>
<td>2,030</td>
<td>2,321</td>
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Source: TA Team estimates.
VI. ALTERNATIVES AND SITE SELECTION

A. Introduction

110. The primary objective of the new heat and power plant is to provide heating to governmental, commercial, and residential customers in UB while the secondary objective is to provide electrical power to UB and Central Energy System. There are different technologies to choose from to meet these two objectives. The heat demand can be met by HOB plants, CHP plants or a combination of both while the power demand can be met by condense power plants or CHP plants. This section describes and compares potential applicable technologies and alternative sites for the new plant and more detailed evaluations on technologies are presented in Section VII and Appendix 3.

B. CHP Technology

111. The potential for use of CHP technology as a measure to save energy is widely accepted internationally. Where it uses modern technology CHP offers improved environmental quality, reduced energy consumption, and improved grid reliability. It has been recognized as an efficient, clean, and economic solution to heating and electricity supply for urban areas. A modern and new CHP plant would be very different from the existing CHP plants in UB. Indeed, many countries around the world have issued various incentive policies for promoting the application of high-efficiency CHP facilities in order to achieve primary energy saving and emission reduction, in particular reduced greenhouse gas (GHG) emissions. As CHP offers great opportunities for efficient use of energy, it can consequently help guarantee the security of energy supply for Mongolia. Extensive studies and investigations conducted by the TA Team have shown that the application of CHP in UB will be highly advantageous due to the City’s long heating season and the stable heat demand.

C. The Alternatives

112. In general, CHP is an efficient, clean, and economical solution to provide heat and electricity supply for urban areas in UB. However, other options must be considered as well to identify the most suitable alternative with respect to the selection of technology and site. Among a number of alternatives evaluated during the inception and interim periods, the TA Team identified and agreed three options with MMRE and ADB, which are believed to both represent the views and the common concerns of local stakeholders, including various Government departments and agencies. These options are described below:

- **Option 1** – A new CHP plant to be built in Uliastai Valley on the eastern outskirts of UB;
- **Option 2** – A new condensing power plant to be constructed at the Baganuur coal mine to produce electricity only, while HOB plants are built in UB for heat supply; and
- **Option 3** – A new CHP plant to be built at the existing CHP3 site and utilize most of the existing infrastructure at the site. The low pressure system of the CHP3 plant would be removed to make room for the CHP5 facilities.

113. Each of the three options has its own advantages and disadvantages. For example,
Option 1 raises environmental concerns associated with underground water sources, and its geological conditions are not ideal. Option 2 involves large land acquisition issues for HOB plants and its overall energy efficiency is low. Option 3 makes best use of existing land and supporting infrastructure, such as existing water supply sources, railway, and roads, etc. However this option would be somewhat more complex to implement, because the heat output from the existing CHP3 plant needs to be maintained throughout the construction of the new CHP plant. More detailed analyses of these three options are presented below and in Appendix 2, including a technical assessment on the technical viability of implementing Option 3 whilst retaining the operational capability of the existing CHP3 plant.

D. Parameters Considered for Comparisons

114. To propose the best scheme for heating and electricity supply in UB, the TA Team has conducted extensive studies and comparative analysis and the results were presented in the Interim Report and Interim Workshop in December 2010. Over 30 parameters in the following categories were considered when evaluating these 3 options, including: i) geological conditions; ii) technology selection; iii) water supply source; iv) railway access; b) power transmission; vi) energy efficiency consideration; vii) environmental protection; viii) land availability and acquisition; ix) resettlement; x) construction works; xi) total capital investment; and xii) annual operating cost.

E. Technology Selection

115. Option 1. Under this option, the new CHP plant would be constructed in Uliastai Valley on the eastern outskirts of UB. Based on the demand forecast (see Section IV) for heating in UB, the CHP5 plant can be constructed in two phases, including Phase I, which would be completed to meet the heat and power demands by 2015, and Phase II, to meet the heat and power demands of UB by 2020. Phase I would have a total design heating capacity of 587 MW (504 Gcal/hr) and a total design power generation capacity of 450 MW. At the completion of Phase II, the total heating capacity would be 1,281 MW (1,101 Gcal/hr) and total design power generation capacity would reach 820 MW.

116. In line with international best practices, the capacity of each individual power generation unit should not be over 15% of the total power generation capacity of the electricity grid, preferably, less than 10%, so as to minimize adverse impact on the entire power supply system with regard to its safety, reliability, and stability. Considering the fact that the total available power capacity of CES is only 615 MW and also that CHP5 is designed to meet both the heat and power demands of UB, especially the much higher heat demand, the capacity of each individual power generation unit is proposed to be 150 MW or less in the case of having a back pressure turbine unit.

117. In total, five super high-pressure steam boilers and one high-pressure steam boiler, each with a capacity of 525 ton/hr, are planned for the CHP5 plant. Boiler selection is to be made taking into account the coal quality, O&M performance, and economic viability, etc. The local coal quality data suggests that either a pulverized coal-fired (PC) boiler or a circulating fluidized bed (CFB) boiler might be chosen. The TA Team evaluated the PC and CFB technologies and took consideration of the local coal characteristics. The CFB boiler technology is recommended for use in the CHP5.

118. Following the principle of “heat supply determining power generation,” the following equipment and technical parameters have been recommended: 5 x 150 MW steam-extraction turbines, plus 1 x 70 MW back pressure turbine, with a total of 820 MW installed power capacity. Under rated steam-extraction volume, the steam-extraction turbine will generate 135 MW power and 280 ton/hr of steam extracting capacity. The back pressure turbine

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16 Characteristics of local coals: heating value > 2800 kcal/kg and Vdaf > 30%.
generates an exhausting steam capacity of 345 ton/hr. The maximum rated heat capacity of six (6) turbines is calculated at 1,281 MW (1,101 Gcal/hr) and the power generation of six (6) turbines is calculated at 745 MW.

119. In addition to boilers, turbines, and generators, auxiliary systems need to be installed as well and they are detailed in Appendix 2.

120. **Option 2.** Under this option, a condensing power plant would be built near the coal mine area of Baganuur for electricity generation plus various coal-fired or gas-fired HOB plants for heat supply to UB. Conceptually, **Option 2** is intended to transfer the power plant (the pollution source), from urban or suburban area to a coal mine mouth so as to mitigate the environmental impact of power plants on urban areas as well as to avoid long distance transportation of coal for power generation. However, it will require construction of long distance high voltage power transmission lines as the current transmission line does not have enough capacity and will result in increased transmission losses compared to **Options 1** and **3**.

121. The condensing power plant at Baganuur coal mine would be designed to meet the power demand of the CES, while in the meantime, a number of HOB plants would need to be constructed in the urban area to satisfy the heating needs of UB. There are a number of technical solutions to HOB option, including coal-fired, biomass-fired, oil-fired, gas-fired, etc.

122. Baganuur coal mine is located approximately 120 km east of UB. Baganuur coal mine has reserved a land area of 80 ha for a new power plant. Tentatively, 4 x 200 MW power generation units would be considered to reach the total power capacity of 800 MW. Similar to **Option 1**, many auxiliary systems need to be installed.

123. **Coal-fired HOB plants.** To meet the total heating demand of 1,281 MW (1,101 Gcal/hr), 20 coal-fired hot water boilers each with a capacity of 70 MW (60 Gcal/hr) are proposed to be installed under **Option 2**. From proven international practices, stoker boilers would be recommended. The boiler parameters should be carefully designed to fit the technical specifications of the available district heating system, assuming that feeding and returning water temperatures are at 135°C/70°C and a design pressure at 1.6 MPa. Technically, 70 MW (60 Gcal/hr) is the maximum value for a stoke boiler and 3~5 boilers should be installed in each boiler house. Ideally, a total of four HOB houses would be constructed, each housing five identical boilers. Subsequently, four link railway lines would be needed for the four HOB plants for transporting coal from coal mines. However, it would be extremely difficult to construct so many large HOB plants with link railway lines in UB. Another approach is to build two big HOB plants, with each housing 10 boilers.

124. **Gas-fired HOB plants.** The feasibility study of the coal gasification program is being planned and the coal gasification facility at Baganuur is planned to be completed by 2015 if the study approves the project is feasible. The syngas pipeline will need to be installed between Baganuur and UB. At the completion of the program, syngas will become available for customers of UB and the environment will be greatly improved when less coal is burned in UB during winter time. However, this project is just at its preliminary stage. The TA Team believes that the syngas option is not currently viable as the feasibility study for this syngas project has yet to be done.

125. Mongolia does not produce LPG and natural gas. LPG could be imported from Russia but it would be costly. It is recommended that a detailed feasibility study on importing LPG be conducted under a separate project. For analysis purpose, LPG is assumed to be available as a fuel to produce hot water for district heating in UB. The fuel supply system and flue system of gas-fired HOB plants are quite different from those in coal-fired HOB plants. Due to the absence of necessary infrastructure for gas buffering, transmission and distribution, many supporting facilities will need to be installed in the plant, including LPG transporting tank trucks, storage tank, gasification devices and associated supply system.
126. To meet the total heating demand of 1,281 MW (1,101 Gcal/hr), 20 LPG-fired hot water boilers would be needed with a capacity of 70 MW (60 Gcal/hr) each. Again, four HOB boiler plants would need to be constructed, each housing five boilers, totaling 350 MW (300 Gcal/hr).

127. As sites for four gas-fired HOB plants cannot be easily identified and selected within a short period of time due to the land requirements, it would be assumed that the gas-fired HOB plants can indeed be installed at suitable sites in UB, but this is an extra risk associated with Option 2 that does not exist with Options 1 or 3. In addition to the boilers, a number of auxiliary facilities similar to Option 1 would be needed.

128. Option 3. Under this option, a new CHP plant would be built at the existing CHP3 site. Technically, specifications for power generation capacity, major equipment, thermodynamic system, and other auxiliary systems would be the same or similar to those of the Uliastai site under Option 1. That is, 5 x 150 MW steam-extraction turbines and 1 x 70 MW back pressure turbine, with total 820 MW installed power capacity.

129. Table 6.1 below lists key technical parameters of the three options.

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
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<tr>
<td></td>
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<td>Uliastai</td>
<td>HOB</td>
<td>Baganuur</td>
</tr>
<tr>
<td>Power Generation Unit</td>
<td>MW</td>
<td>5x150+1x70 =820</td>
<td>0</td>
<td>4x200 =800</td>
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<td>Heat Supply Unit</td>
<td>Gcal/hr</td>
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<td>4x5x60 =1,200</td>
<td>0</td>
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<tr>
<td>Designed Power Capacity</td>
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<td>800</td>
<td>820</td>
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<tr>
<td>Designed Heat Supply Capacity</td>
<td>Gcal/hr</td>
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<td>1,200</td>
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<td>Heat Demand</td>
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<td>1,101</td>
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<td>Yearly Power Generation</td>
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<td>Transmission Loss</td>
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<td>Yearly Net Heat Supply</td>
<td>million Gcal</td>
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<td>3.0</td>
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</table>

Source: TA Team estimates.

F. Energy Efficiency Consideration

130. One of the advantages of CHP is its high level of fuel utilization efficiency. The overall energy efficiency of a conventional electric-only plant is about 33%, the remaining two-thirds of energy is wasted through the stack gas and cooling system. In contrast, a CHP process can use the energy twice and the overall thermal efficiency for the proposed CHP options could reach 59.7%.
131. Due to higher efficiency of CHP technology, the coal consumption for Option 1 and Option 3 is much lower than Option 2. Specifically, the CHP options will save up to 30% of fuel consumption per kWh electricity generated in comparison with the conventional electric-only power plant. Further, a CHP scenario will consume 20~30% less fuel per GJ heat produced in comparison with HOB plants. Totally, a CHP solution could save 0.99 million ton of raw coal each year, as compared to a condensing power plant and coal-fired HOB under Option 2. Table 6.2 below lists detailed comparison data of energy efficiency under the three options.

132. The ash watering and spraying cooling systems that have been applied in CHP3 result in extremely high water consumption. Since 2000, the yearly average water consumption for CHP3 has remained at about nine million tons. The proposed new CHP plant should be designed to use a dry ash removing system and more efficient modern water cooling towers, which would conserve much more water when compared with CHP3. Based on a preliminary estimation, the water consumption of the new CHP plant is approximately 8.1 million tons per year while it has five times of power generation capacity and three times of heating capacity compared to that of CHP3. The new CHP plant would conserve more than 1 million tons of water each year in comparison with the consumption of option 2. Table 6.3 presents specific coal and water consumption information for the three options.

**Table 6.2: Energy Efficiency Comparisons**

<table>
<thead>
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<th>Item</th>
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<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>CHP at</td>
<td>HOB in UB</td>
<td>Baganuur Power Plant</td>
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<tr>
<td>Power Generation</td>
<td>%</td>
<td>46.7</td>
<td>--</td>
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<td>Heat Generation</td>
<td>%</td>
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<td>Total Thermal Efficiency</td>
<td>%</td>
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<td>Specific Fuel Equivalent Consumption for Heat Generation</td>
<td>kg/GJ</td>
<td>38.3</td>
<td>48.7</td>
<td>38.3</td>
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</table>

*Source: TA Team estimates.*

**Table 6.3: Coal and Water Consumption Comparisons**

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<th>Item</th>
<th>Unit</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CHP in Uliastai</td>
<td>HOB in UB</td>
<td>Baganuur Power Plant</td>
</tr>
<tr>
<td>Yearly Fuel Consumption</td>
<td>million tce/a</td>
<td>1.56</td>
<td>0.61</td>
<td>1.52</td>
</tr>
<tr>
<td>Baganuur Coal</td>
<td>million ton/a</td>
<td>0.99</td>
<td>--</td>
<td>3.09</td>
</tr>
<tr>
<td>Shivee-Ovoo Coal</td>
<td>million ton/a</td>
<td>2.63</td>
<td>1.52</td>
<td>--</td>
</tr>
<tr>
<td>Total Raw Coal Consumption</td>
<td>million ton/a</td>
<td>3.62</td>
<td>4.61</td>
<td>9.27</td>
</tr>
<tr>
<td>Water Consumption (Water Cooling)</td>
<td>million ton/a</td>
<td>8.1</td>
<td>1.71</td>
<td>7.56</td>
</tr>
</tbody>
</table>

*Source: TA Team estimates.*
G. Geological Conditions and Safety

133. **Option 1.** The geological conditions around the site for Option 1 are complicated. The earthquake grade is seven degree and a few active faults have been identified on the eastern outskirts of UB and not far from the proposed CHP 5 site in the Ulasitai valley. The TA Team engaged the Research Center of Astronomy and Geophysics of the Mongolian Academy of Sciences to perform the detailed geological assessment of the specific project site. The seismic hazard assessment report concluded that the Gunjiin fault is active and it passes Uliastai Valley approximately 1 km north of the proposed site. The Gunjiin fault presents a serious seismic hazard to the proposed CHP5 plant.

134. In addition to the active fault already identified, the proposed site under Option 1 is bordered to the mountain area in the northeast and to the river in the southwest. The site is therefore facing potential risks of flooding.

135. **Option 2.** The geological conditions of this site are moderately complicated. Old faults have been identified 18~20 km to the southwest of the site in Baganuur. The earthquake grade is seven degree and there are potential risks of flooding and permafrost near the site.

136. **Option 3.** The existing CHP3 site has relatively reliable geological conditions. No evidence of active faults has been identified near the site. The earthquake grade is eight degree and thus the earthquake risk must be mitigated by special technical measures.

H. Land Acquisition, Resettlement, and Site Preparation

137. **Option 1.** It is estimated that a total land area of 51 ha is needed for the construction of the new CHP plant. The government has approved 30 ha of land in Uliastai Valley for the proposed CHP5 plant. As the 30 ha of land is required to meet the power generation capacity of 450 MW designed for Phase I of the CHP5 plant, additional land areas are required to complete Phase II. Due to typical geological conditions that feature in the Uliastai Valley, more earthwork will be required for site preparation, including leveling of the land.

138. The ash yard for the new CHP plant would require an area of 35 ha to provide an ash storage capacity of 10 years. However, the TA Team believes that the ash generated from the plant can be beneficially used as raw materials in the construction sector based on detailed analysis on ash radiation performed by Radiation Lab of the University of Science and Technology.

139. There is no access road to the site in Uliastai. There is also no railway to the site for transporting coal. It is estimated that 3 km of access road to the plant and a 5 km road for transporting ash will need to be constructed. Additionally, an approximately 2 km-long link railway will need to be constructed to connect the main railway and the plant.

140. Our understanding is that although the proposed site in Uliastai is very close to one of the main drinking water sources of UB, the CHP plant will not be allowed to take water directly from the water source. Therefore, an additional 14 km of water supply pipeline from the water pump station to the new CHP plant will need to be constructed.

141. The new CHP plant at the Uliastai site would be connected to the existing district heating system of UB. As the new CHP plant is to be constructed in two phases, two heating pipelines are to be installed. One should be sized DN1400 and would have a length of 7.2 km, running along the southern part of the heating area and another, also sized DN1400, with a length of 8.9 km would run along the northern part of the heating area.

142. **Option 2.** Under this option, the total land area of 45 ha would be required for construction of the proposed condensing power plant near the Baganuur mine. Ash yard for
the proposed condensing power plant would require an area of 35 ha. The ash yard should be lined with water-tight materials to protect underground water from being polluted by the ash.

143. It is estimated that a 5 km-long road for transporting ash will need to be constructed and a 3 km-long railway is to be constructed for the power plant. In addition, an 8 km-long water pipeline will also need to be installed.

144. A total land area of 25 ha is required for construction of the proposed four HOB plants. The ash and slag yard for the proposed HOB plants would require an additional area of 30 ha. Because ratio of slag to ash from stoker boiler is normally higher than 70:30 and slag is not easy to be utilized in construction material, it is required to construct a long term ash and slag yard. Similarly, the ash yard should be lined with water-tight materials to protect underground water from being polluted by the ash.

145. Site surveys and selection for HOB plants might involve a complicated process and it would be wise to look at some of the available sites or sites already surveyed and/or studied. The candidate sites for construction of the four proposed HOB plants are the sites in Ulaanbaatar and CHP2 or CHP3. However, to have a better hydraulic balance of the heating network, the HOB plants should be constructed in the east and north parts of UB as the existing heating sources are located in the south and southwest of UB. The Ulaanbaatar site and the US-15 HOB plant site could be considered for HOB plant sites.

146. The TA Team visited the US-15 HOB plant site and performed a preliminary assessment. The site is located in the east part of UB and west of Ulamnai Valley. The existing fenced area is very small (roughly only a few hectares). The US-15 site is surrounded by enterprises, ger households, and a school. Thus, to convert this site to a new HOB plant site, there would be some land acquisition and resettlement of some ger households and other entities. Since the proposed CHP5 plant requires much larger land area than HOB plant, the land acquisition and resettlement would be even more challenging. In addition, the active Gunjiin fault also closes to the US-15 HOB plant site.

147. **Option 3.** Under this option, a total land area of 50 ha is required for construction of the new CHP plant. The existing CHP3 site has plenty of land area. However, since the Government only allows the low-pressure system of the existing CHP3 plant to be removed, small amount land (approximately 2.5 ha) would need to be acquired at the west side of the plant.

148. The existing ash yard has some remaining capacity (approximately 11 ha) but not enough for the new CHP5 plant. Therefore, the TA Team explored the options of beneficial use of the fly ash and bottom ash as construction materials or raw materials for cement or brick manufactures.

149. The CHP3 site has existing infrastructures that can be utilized by the new CHP plant. For example, there are roads accessible to the CHP3 and railway links to the plant from the UB train station.

150. These existing heating pipelines are highly suitable for use by the proposed CHP5 plant. In addition, to meet the full capacity of the new CHP plant, an additional 16.7 km-long heating pipeline with maximum DN1200 in diameter is estimated to be required under Option 3.

151. The existing 220 kV transmission lines in the CHP3 could also be utilized in the proposed CHP5 plant. To meet the requirement of the new plant, a 9 km length of 220 kV overhead line connecting to the CHP4 transformer station would need to be rehabilitated.

152. The comparative analysis of the land and resettlement works needed and site-related engineering works likely required under the three options are shown in Appendix 2.
I. Build-and-Scrap Arrangement for Option 3

153. Under Option 3, the low pressure system of CHP3 will be decommissioned while the HP system of the plant will be kept. The CHP3 plant will be under normal operation while the Phase I of CHP5 is being constructed. Thus, a build-and-scrap methodology will be needed to ensure a smooth transition so that the customers of the low-pressure system of CHP3 will not be affected. A well-designed implementation program needs to be developed to coordinate all involved activities and ensure uninterrupted and stable heating and power supply to UB.

154. CHP5 plant will be built in two phases under this option. Phase I will reach a total design power generation capacity of 450 MW and total design heating capacity of 587 MWt (505 Gcal/hr), during which a 3 x 150 MW steam extracting units are to be installed. These three units will be installed first in the open area at the west side for taking over the heating supply and power supply duties currently performed by the CHP3 low pressure system which will be decommissioned once the three new units are operational. Shortly after the decommissioning of the low pressure system is over, the units for Phase II will be installed in a space previously occupied by the low pressure system building.

J. Environmental Impact

155. All three options all involve some environmental issues including air pollution, water discharge, and waste management. Option 1 might have some air pollution issues due to local prevailing wind, which could be minimized by technical solutions, such as installing emission control equipment and tall stacks. Since proven technical solutions to control water and air pollutions from power plants are commercially available, it should not be a major issue to control water pollution and fugitive dust generated from the ash yard. Under Option 2, the power plant is far from the UB urban area and therefore the air pollution impact on UB is minimized. However, the five HOB plants in UB might have some serious air pollution issues if they are not controlled properly. In addition, ash generated from the HOB plants needs to be transported out and there might be fugitive dust issues near residential areas. Option 3 would have relatively less environmental impact as the site is an existing CHP3 site located in the industrial area and it also has its own ash yard. All environmental issues associated with Option 3 could be addressed through effective technical solutions and mediation measures.

156. Overall, Option 3 has the least environmental impact comparing to the other options. More detailed information on the environmental impact assessment is presented in Section VIII and Appendix 4 of this report.

K. Financial Analyses

157. It is estimated that the investment cost of Options 1 and 3 will be less than that of Option 2, assuming that Option 2 needs to be equipped with the same flue gas desulphurization and PM control equipment as Options 1 and 3. For operation costs, coal consumption is the major operation cost for all three options. The calculations show that Options 1 and 3 can save at least 30% of coal consumption due to its inherent higher thermal efficiency of CHP technology, compared to Option 2.

158. Capital investment as well as operating costs for the three options are estimated and shown in Table 6.4. Comparatively, the total investment cost of Option 1 is estimated to be $88 million more than that of Option 3, while the total investment cost of Option 2 is estimated to be $310 million more than that of Option 3. The annual operating cost of Option 2 is estimated to be $21 million per year more than that of Options 1 and 3.
Table 6.4: Comparisons of Investment and Operational Cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Investment</td>
<td>Million USD</td>
<td>598</td>
<td>700</td>
<td>564</td>
</tr>
<tr>
<td>Phase I: 450 MW capacity</td>
<td>Million USD</td>
<td>1,085</td>
<td>1,307</td>
<td>997</td>
</tr>
<tr>
<td>Phase I and II: 820 MW capacity</td>
<td>Million USD/yr</td>
<td>47</td>
<td>54</td>
<td>47</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>Million USD/yr</td>
<td>89</td>
<td>110</td>
<td>89</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

L. Conclusion

Based on the above comparative analyses, it can be concluded that Option 3 is the best option for the proposed new CHP plant in UB. It can modernize and revitalize the CHP3 plant. Most of the existing infrastructures at CHP3 can be utilized. The build-and-scrap approach can be applied to build a new CHP plant while the existing low-pressure system of CHP3 plant continues to operate until Phase I of the new CHP plant is operational. Additionally, Option 3 will bring environmental benefits to UB as air emissions will be reduced and water consumption per unit of energy generation will be significantly decreased. The UB Municipality and the Ministry of Mineral Resources and Energy have also endorsed this option.
VII. CONCEPTUAL DESIGN OF THE NEW CHP PLANT

160. An important task of the TA is to prepare a conceptual design of the proposed CHP5 plant based on the feasibility study performed by the TA Team. All technical issues associated with the conceptual design of the CHP plant are summarized in this section of the report while the full technical feasibility of the CHP5 plant including drawings for major systems of the plant is presented in Appendix 3.

A. Fuel Supply

1. Coal Resource and Estimated Consumption

161. It is estimated that Mongolia's total proven coal reserves are approximately 12 billion tons and productive resources are 6.2 billion tons. At present, more than 200 coal deposits within 12 coal basins and 3 regions are known in Mongolia. There are approximately 40 licensed coal mines with different capacity around the country. Most coals are sub-bituminous to lignite in the east and bituminous in the west. In 2009, total coal production was 7.7 million tons per year, of which 5.23 million tons were used for power generation. However, the infrastructures for mass production of many mines are not in place yet.

162. There are two big coal mines at Baganuur and Shivee-Ovoo coal deposits that are within reasonable distance from UB and can supply coal the CHP5 plant. The TA Team recommends that 70% of the coal consumption can come from Shivee-Ovoo coal mine while the remaining 30% will come from Baganuur coal mine. It is estimated that the CHP5 plant will need approximately 3.62 million tons of coal for both Phase I and II (2.63 million tons from Shivee-Ovoo and 0.99 million tons from Baganuur coal mine) based on the heating contents of the coal from these two mines. Phase I will need 1.83 million tons (1.33 million tons from Shivee-Ovoo and 0.5 million tons from Baganuur).

163. The TA Team visited both mines and discussed with the management of the mines. We concluded that both mines do not have enough spare capacities to provide the coal to CHP5 plant without significant expansion of the mining operations. In order to meet the coal demand by Phase I of CHP5 plant in 2015, the mines will likely need to start the removal of some overburdens in 2012. Thus, it is urgent to start the feasibility study for the expansion of these two mines in 2011.

2. Coal Quality

164. Baganuur coal moisture content is high as 33%. Ash content on average is more than 9.5% and the average heating value of the lignite coal is about 3,400 kcal/kg. The coal is a low sulfur coal with sulfur content is 0.36%.

165. The Shivee-Ovoo coal quality is characterized by high moisture contents, which can be as high as 45%. Ash content is in the range of 7.1-11% with an average of 8.5% and the average heating value of the coal is about 2,900 kcal/kg. The sulfur content of the coal is approximately 0.9%.

3. Coal Transportation

166. The Mongolian railway is comprised of two separate railways: the Trans-Mongolian main line of 1,110 km long and the Bayantumen Railway of 239 km long. The total length of the Mongolia Railway, including branch lines is 1,815 km. Total railway distance from Baganuur mine to current CHP3 power plant site is approximately 191 km. The railway
distance between Shivee-Ovoo mine and CHP3 power plant site in UB is approximately 259 km. Coal is transported by the railway system from both mines to UB power plants through two stations in UB.

167. Regarding the coal transportation by railway, TA Team has consulted Mongolian-Russian Joint Stock Ulaanbaatar Railway (UBTZ). The UBTZ has issued an official letter concerning the requirements of transporting coal these two mines to CHP3 site. They concluded that the main railway has enough capacity while improvements will be needed for branch lines from UB station to CHP3 site and at the coal mines. Details are provided in Appendix 3 of this report.

B. Site Condition of CHP5

1. General Description of the Site

168. It is proposed to construct the CHP5 plant on the existing CHP3 site. The CHP3 covers an area of about 88 ha. It has two main buildings and several auxiliary buildings. There is a branch linking railway from the CHP3 plant to the UB train station. Road access to the plant is available. Other utilities, such as water service system, sewage system, telecommunication, etc. are all available. The site condition in general is good for the CHP5.

2. Hydrographic and Meteorological Condition

169. Mongolia has four distinct seasons. The extremely cold winter is the longest season in Mongolia. The mean annual temperature in UB city ranges between -0.9°C to 2.4°C, and winter is cold with an average temperature of -19.3°C to -22.5°C. In summer, an average temperature ranges between +14.3°C to +15.3°C. The average annual precipitation ranges from 249 to 261 mm, in which 180-190 mm falls during the warm season, including 75-80% in the summer, especially in July and August. In winter, average 5-7 mm precipitation falls. It rains for 40-70 days each year, snows 25-30 days, and 140-170 days are observed having snow coverage. During the spring from April to May, it is dry and windy, and the average relative humidity is only 47% and 45% in April and May, respectively. The yearly average relative humidity is 62% and the annual average wind speed is 2.5 m/s.

3. Water Source

170. Available water source for CHP5 can be found from the CHP3 water source. It is estimated that the total water consumption of the CHP5 will be 8.1 million tons per annum. Hydro-geologically, it is in a favorable condition of being on the terrace of the Tuul river. Ground water level is 1.5 m. There is existing water supply system with 41,300 m³/day reserve estimated before 70s, including 36,122 m³/day of category A and 31,097 m³/day of category C₂ in 2007. Each day, approximately 16,000 m³ of water is produced from this reserve. In addition, with the implementation of the CHP5, the low pressure system of CHP3 can be decommissioned. Consequently, the existing CHP3 water supply system can be used for new CHP5 and no need to establish a new water supply system for Phase I. A water resource study will be needed to assess whether there is enough water resource for Phase II.

4. Geotechnical Conditions

171. The foundation of the CHP3 site consists of a thick alluvium deposit of quaternary age and is geologically stable. There is not any observed active fault near the site. Earth quake grade is magnitude 8. Seasonal freezing depth is 2.5 m and there is no permafrost at the site. There are not any engineering geological phenomena and processes observed in the CHP3 area. Detailed geotechnical conditions are described in Appendix 3 of this report.
5. Conditions of the Ash Yard

172. The ash yard is situated 0.5 km west of the project site. In order to conserve water and recycle ash, we propose using dry ash removal technology. The conditions of the ash pond were investigated and it is suitable for ash storage. The height of the ash pond is 11 m and the storage capacity is approximately 1.5 million m$^3$. If the ash cannot be recycled, capacity of the existing ash pond can match the ash quantity accumulatively produced by CHP5 before 2024 and new ash pond should be found for CHP5 after 2024. However, a market study in 2011\textsuperscript{17} indicates that there is enough demand for all ash produced by CHP5 plant as construction materials.

6. Anti-disaster Ability Evaluation

173. In the process of selection of plant site and layout plan, the regional stability and site stability of plant site have been considered. The construction site is at regional crust stable block, away from regional active fault zone, and it is not likely to suffer from major landslide, collapse, mudslide, surface collapse, and other geological disasters. The stabilization and safety of the plant site are acceptable. The Project will be designed according to international practices and power plant design criteria and specifications. Relevant design criteria and principled design alternatives meet corresponding counter-disaster requirements of power plants construction.

C. Installed Capacity and Key Indicators of CHP5

1. Technical Principle

   a. Rationale of Application of CHP Technology

174. Coal-fired power plants dedicated to electric power generation and using the latest commercially available advanced technologies will generally operate at overall net efficiency of approximately 40% or less. Significant amounts of energy are lost during the steam condensation segment of the Rankine cycle due to heat transfer into the cooling water. However, CHP technology, also known as cogeneration, allows recovery of some of the heat that would otherwise be wasted in cooling water and improving the overall energy utilization efficiency as high as 50~80%.

   b. Strategy of “Power Determined by Heat”

175. Extensive studies and investigations conducted by the TA team have indicated that in addition to its technical, environmental, financial, and economic benefits, application of CHP in UB will be significantly advantageous due to its inherent eight-month long heating season and stable heat and hot water demand. It has been greatly appreciated that a reliable heating service is not merely a utility for citizens of UB; it is indeed a matter of life and death. Therefore, a safe, clean, and reliable heating supply is a critical need for the entire population of UB. The principle of “Power Generation Determined by Heat Supply” will be fully followed in engineering the installed capacities and selection of turbines for the proposed CHP5 plant.

   c. Principles of Designing a CHP Plant

176. A CHP plant should be designed according to a city master plan, urban district heating plan and cogeneration plan to specify planned capacity, construction schedule, and operational arrangement. The installed capacity and units of the proposed CHP plant should be designed to fit the heating loads and power grid capacity of UB.

\textsuperscript{17} Coal Ash Utilization Market Study, March 2011. Mongolian Association of Building Material Manufacturers
177. International specifications and proven practices suggest that a CHP plant with a stable heating load (daily load fluctuation rate of 10%~20%) should consider installing a back pressure unit or extraction steam back pressure turbine unit, so as to reduce investment cost, save energy consumption, and gain better economic benefits.

178. In general, for a CHP plant with an unstable heating load it is suggested to install a combined unit of an extraction condensing steam turbine and back pressure or extraction steam back pressure systems.

179. For a CHP plant with a high heating load fluctuation rate it is suggested to install an extraction condensing steam turbine. However, the overall yearly average heating efficiency should be greater than 45% and yearly average heat-power ratio should be greater than 50%.

180. Small size condensing steam turbine is recommended for a CHP plant located near a coal mine burning low rank coal.

181. Steam pressure required by a turbine depends on the unit size and the general classifications are as follows:
   i) Unit capacity of 1.5 MW - sub-medium or medium pressure parameter;
   ii) Unit capacity of 3 MW - medium pressure parameter;
   iii) Unit capacity of 6 MW and 12 MW - sub-high pressure parameter;
   iv) Unit capacity of 25~100 MW - high pressure parameter;
   v) Unit capacity of 100 MW – super-high pressure; and
   vi) Unit capacity > 300 MW – subcritical pressure or supercritical pressure.

182. Boilers are suggested to be selected based on total heating capacity, total power generation capacity, technical performance, type of coal available, commercial availability, O&M performance, and capital investment, etc. Detailed comparative analysis of boiler selection is described in Appendix 3 of this report.

183. Turbine capacity should be compatible with boiler capacity to meet specified requirements under various heating load conditions. Verifications must be made to ensure that the total inlet steam is not lower than the minimum stable combustion loads without fuels being fed under the minimum heating load condition so as to ensure a safe, stable and cost-effective operation of the boiler. The condensing inlet steam must be designed to ensure a safe and stable operation under minimum condensing conditions.

2. **Installed Capacity of the CHP5**

184. Based on the heating demand and power demand forecast and to follow the principle of “Power Generation Determined by Heat Supply”, 5 x 150 MW steam extracting turbines, plus a 70 MW back-pressure turbine are recommended. Based on the detailed calculations, the maximum combined heating capacity of six turbines will be 1,281 MWt (1,101 Gcal/hr) and the power generation of six turbines will be 820 MW, under the maximum heating capacity. The project is planned to be implemented in two phases. During Phase I, 3 x 150 MW steam extracting turbines, with total 587 MWt (505 Gcal/hr) heating capacity, are planned. During Phase II, additional 2 x 150 MW steam extracting turbines and a 70 MW back-pressure turbine will be installed.

3. **Key Indicators of the CHP5**

185. The key indicators of the CHP5 are shown in the Table 7.1.
### Table 7.1: Key Indicators of the CHP5

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>Total Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Power Generation Capacity</td>
<td>MW</td>
<td>820</td>
</tr>
<tr>
<td>Installed Heat Supply Capacity</td>
<td>MWt</td>
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</tr>
<tr>
<td></td>
<td>Gcal/hr</td>
<td>1,101</td>
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<tr>
<td>Heat demand</td>
<td>MWt</td>
<td>1,281</td>
</tr>
<tr>
<td></td>
<td>Gcal/hr</td>
<td>1,101</td>
</tr>
<tr>
<td>Yearly Power Generation</td>
<td>million kWh</td>
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</tr>
<tr>
<td>Internal consumption</td>
<td>million kWh</td>
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<tr>
<td>Transmission Loss</td>
<td>million kWh</td>
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<tr>
<td>Net Power Supply</td>
<td>million kWh</td>
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</tr>
<tr>
<td>Internal heat consumption</td>
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<tr>
<td></td>
<td>million Gcal</td>
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</tr>
<tr>
<td>Yearly Net Heat supply</td>
<td>million GJ</td>
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</tr>
<tr>
<td></td>
<td>million Gcal</td>
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<tr>
<td>Average Annual Ratio of Heat to Power</td>
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<td>0.84</td>
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<td>Efficiency</td>
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</tr>
<tr>
<td>Power Generation</td>
<td>%</td>
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</tr>
<tr>
<td>Heat Generation</td>
<td>%</td>
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</tr>
<tr>
<td>Total Thermal efficiency</td>
<td>%</td>
<td>59.7</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Coal Consumption Per kWh</td>
<td>g/kWh</td>
<td>263</td>
</tr>
<tr>
<td>Standard Coal Consumption Per GJ</td>
<td>kg/GJ</td>
<td>38.3</td>
</tr>
<tr>
<td>Stand Coal Consumption</td>
<td>million tce</td>
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</tr>
<tr>
<td>Baganuur Coal</td>
<td>million ton (raw)</td>
<td>0.99</td>
</tr>
<tr>
<td>Shivee-Ovoo Coal</td>
<td>million ton (raw)</td>
<td>2.63</td>
</tr>
<tr>
<td>Raw Coal or LPG</td>
<td>million ton (raw)</td>
<td>3.62</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

D. The Plant Site

1. External Condition of the Plant

186. The water circulation cooling system is applied for the Project, whereas ground water is supplied for industrial make-up water. The railway is accessible to the power plant. A dedicated line starts at the UB station and arrives at the plant area. Internal lines should be expanded and improved to meet the increased transportation capacity.

187. The ash yard is located in the west, about 0.5 km away from the plant. The storage capacity of the ash yard will meet the ash volume until 2024.

188. The power plant will supply most of the heat to customers residing in middle and east areas of UB, where the new route starts at the industrial district area, via 5A Primary Pipeline, the EA building, Dundgol River Dam, Peace Bridge, then returns back to Sun Road and branches at Narantuul Market, finally being hooked up to the existing pipelines.
189. The project site is accessible by road however some of the existing roads need rehabilitation. The access road to ash yard should be constructed from west side of the plant site up to the ash yard. Total length of the new road is about 0.5 km. The construction yard is tentatively built within the plant area, covering total land area of 3.0 ha.

2. New Site Arrangement for the CHP5

190. The CHP5 is proposed to be constructed in two phases at the location within the existing CHP3, where its high-pressure system is to be maintained and its low pressure system is to be removed. The HP system is located in the center and the low pressure system in the east part of the site. CHP5 is to be constructed on both sides of the HP system.

191. There are two options for constructing Phase I and II at the site. Option 1 is to locate Phase I on the east part of the property next to the low pressure system while option 2 is to locate Phase I on the west side of the property where there is an open area. Detailed comparisons are presented in Appendix 3 and the conclusion is that option 2 is recommended and its main advantages are as follows:

192. Construction of Phase I make relatively minor impacts on the normal operation of the existing facilities and provides more flexibility for smooth transition from old production into new one, primarily due to the fact that it does not require actions to decommission the low pressure system and relocation of offices in advance.

193. Two new cooling towers will be located in the west side, and the third one in the northeast corner. Phase I requires two cooling towers while Phase II requires one cooling tower. Therefore it is more logical to put Phase I near the cooling towers at the west side.

194. The 220kV overhead transmission lines will be readily connected to the urban 220kV grid, which reduces the cost and level of construction difficulties.

a. General Layout

195. The layout of the plant will adopt three-array arrangement form. The production auxiliary facilities are installed around the main plant.

196. Two water cooling towers and circulating pump house for Phase I will be installed in the northwest corner of the project site and one water cooling tower and circulating pump house for Phase II will be installed on the northeast corner of the site. Thus, the cooling towers for both phases are installed close to the main plants of Phase I and Phase II.

197. The 220kV switch yard proposed for Phase I will occupy the space currently used by the existing spray cooling pool. The space currently used by the existing switch yard of low pressure system will be used by the switch yard of Phase II. The 220kV transmission lines for Phase I can be easily connected with 220kV overhead transmission lines of UB with no need to cross over the 110kV lines. For Phase II, the 220kV lines can be connected to the 220kV switch yard internally.

b. Construction Sequence

198. Construction of Phase I will not require relocation of office. The spray cooling pool of the low pressure system will be dismantled, while the boilers of low pressure system will be remained. Meanwhile, electricity of LP can be easily covered by other sources, and it is allowed for low pressure system not to generate electricity. Therefore, we proposed that the low pressure system will only generate steam for heating, and not generate electricity before CHP5 is put into service. In this case, the steam from low pressure system boilers will directly go to the heating exchangers for heating up the hot water for district heating system and industry customers through reducers and not go to turbine for power generation. The spray cooling pool is not required for this operating scenario. low pressure system will be
decommissioned once the Phase I of CHP5 is put into service. The site of the spray cooling pool will be used for switch yard for Phase I. The 35kV substation will be relocated to the north of the 110kV switchyard to ensure power supply for the existing customers.

199. The main plant of Phase I can be constructed easily as it’s located in an open area in the west side. Switch yard can be constructed on the site of the existing spray cooling pool. Civil work for water treatment facilities, waste water treatment facilities, and other auxiliary will be completed during Phase I. The related equipments can be installed by phases.

200. Coal yard proposed for Phase I will be constructed on the area close to the existing coal yard. Additional systems and facilities are to be installed including one new bucket wheel stacker and reclaiming auxiliary for the coal conveying system. The coal is transported from the coal yard, through the belt conveyor, transfer stations, and coal crusher room, the fixed end of main power house, then fed to the coal bunkers of each boiler. Under Phase II, the coal yard is to be extended further east, and the storage capacity of the coal yard needs to be increased to meet the demand of both Phase I and Phase II. The existing coal yard for the CHP3 is to be upgraded and one additional bucket wheel stacker and reclaiming and related auxiliary equipment are to be installed. Coal for Phase II will be transported by other conveying system in the west side.

201. Once Phase I is put into operation, the low pressure system and its auxiliary facilities can be fully decommissioned and the remaining two boilers and turbines, generators and other equipment and facilities will be installed on the site previously occupied by the low pressure system. At the same time switch yard proposed for Phase II will be installed at east side of the switch yard of the HP system. In addition, one cooling tower is to be constructed on the northeast corner of the site.

E. Main Equipment Selection

1. Turbine Selection

202. Based on the heating demand and power demand forecast, following the principle of “Power Generation Determined by Heat Supply”, five units of steam-extraction turbines with capacity of 150 MW each, plus one 70 MW back pressure turbine are recommended. Under rated steam-extraction volume, the steam-extraction turbine will generate 135 MW power and 280 ton/hr of steam extracting capacity. The back pressure turbine generates an exhausting steam capacity of 345 ton/hr. Under the maximum heating capacity, the maximum heating capacity of six turbines is 1,281 MW and the power generation of six turbines is 745 MW. Detailed analysis for turbine selection is described in Appendix 3 of this report.

2. Boiler Selection

203. The studies suggest that stoker-fired boiler is not a good technical solution to be recommended for use in the proposed CHP5, because it has relatively outdated technology compared to other emerging newer coal combustion technologies.

204. Cyclone coal combustion technology is no longer competitive because of the commercial availability of other technologies including fluidized-bed combustion technology and therefore it is not a good option for the proposed CHP5 power plant.

205. Coal gasification combustion technology has limited application to date in electrical power generation and heating supply worldwide. Though there might be some cases where some new proposed power generation projects using coal gasification as part of Integrated Gasification Combined Cycle (IGCC) plant, it is however not a favorable technical solution to the new CHP5 power plant.

206. Coal water mixture (CWM), also called coal water slurry fuel (CWSF) combustion
technology was just used in pilot projects, and not widely used in the power sector. The CWM using lignite is not commercially proven up to now. Normally, bituminous coal is more suitable for preparing CWM. The overall efficiency of CWM technology is lower than CFB technology. The operation cost is much higher than the CFB boilers due to expensive CWM and more fuel consumption. If the CWM would be used for a power plant, a large-size CWM plant would also need to be constructed near the coal mine, and the transporting pipeline from CWM plant to power plant and intermediate pump stations have to be installed, which will be complicated and expensive. Anti-freezing facility will increase both the capital cost and operation cost. Based on the situation of UB, it is not feasible to use the CWM as the fuel for big power plant. It would be suitable to select HOBs for modification into CWM boilers as pilot projects, through which the CWM would be demonstrated commercially using Mongolian lignite coal.

207. Pulverized-coal combustion or PC boilers have been predominately used in the existing power plants of many countries around the world. In 2008, PC boilers consumed about 92% of total coal consumed by the power plants in US. Currently the PC combustion has been the predominate design of choice for new large coal-fired power plants (>400 MW) built in US.

208. However the PC boilers have some disadvantages. The international practices indicate that frequent maintenance is needed due to severe abrasion of the pulverizer. In addition, equipment to remove nitrogen oxides (NOx) and sulfur dioxide (SO2) emissions must be installed since NOx and SO2 are emitted during combustion. This will consequently increase the cost and reduce the overall operational efficiency.

209. Circulating fluidized-bed (CFB) combustion technology is a relatively new technology and was developed for solid fuel combustion. CFB technology is inherently suited for various fuels, including low-grade fuels such as petroleum coke, coal refuse, municipal waste, and biomass materials. Even though CFB boilers do not constitute a large percentage of the total industrial boiler population, they have gained popularity in the last few years, due primarily to their capabilities to burn a wide range of solid fuels and their low NOx and SO2 emission characteristics. The combustion temperature of a CFB boiler (800~900°C) is significantly lower than a PC-fired boiler (1,300~1,500°C), which results in lower thermal NOx formation and the ability to capture SO2 with limestone injection in the furnace.

210. There are also some disadvantages for CFB boilers, including abrasion of combustion chamber, higher level of operational skills, etc. These could be resolved by well designed maintenance procedures and training. Overall the CFB technology is technically matured, operationally reliable, commercially available, and economically viable, it is therefore recommended for application in the CHP5.

F. Technical Specifications of Main Equipment

1. Boiler

211. As proposed, three 525 ton/hr super high-pressure boilers will be installed under Phase I, while two 525 ton/hr super-high pressure boilers and one 525 ton/hr high-pressure boiler are installed under Phase II. The boiler is of design of high temperature, super-high pressure, drum-type natural circulation, single furnace, one-time reheating balanced-draft, circulating fluidized bed technology, indoor arrangement, dry bottom and full-steel frame, and complete suspended structure. Light diesel is to be used for boiler ignition and combustion aid. The lowest non combustion-aid rate is 30% of Boiler Maximum Continuous Rating (BMCR). The boiler's main technical parameters are shown in Table 7.2.
Table 7.2: Boiler’s Main Technical Parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>BMCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam flow at maximum continuous rating</td>
<td>ton/hr</td>
<td>525</td>
</tr>
<tr>
<td>Superheater outlet pressure</td>
<td>MPa(g)</td>
<td>13.7</td>
</tr>
<tr>
<td>Superheater outlet temperature</td>
<td>°C</td>
<td>540</td>
</tr>
<tr>
<td>Feet water temperature</td>
<td>°C</td>
<td>248.9</td>
</tr>
<tr>
<td>Primary air temperature at AH outlet</td>
<td>°C</td>
<td>244</td>
</tr>
<tr>
<td>Sec air temperature at AH outlet</td>
<td>°C</td>
<td>244</td>
</tr>
<tr>
<td>Gas air temperature at AH outlet</td>
<td>°C</td>
<td>140</td>
</tr>
<tr>
<td>Consumption of coal</td>
<td>ton/hr</td>
<td>71.9</td>
</tr>
<tr>
<td>Calculated boiler efficiency (calculated by LHV)</td>
<td>%</td>
<td>91.45</td>
</tr>
<tr>
<td>Guaranteed boiler efficiency (calculated by LHV)</td>
<td>%</td>
<td>91</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

2. Steam Turbine

212. Under condensing mode and rated steam extracting condition, each steam-extracting turbine will have 135 MW of power generation capacity and steam-extracting capacity of 280 ton/hr. Based on the detailed calculations, under rated steam-extracting condition, the rated heating capacity of three turbines under Phase I will be 587MWt (1,281 MWt for both phases). Under the rated heating capacity the rated power generation of three turbines for Phase I will be 405 MW (745 MW for both phases).

213. The extracting and condensing steam turbine will have the configuration of high pressure, double cylinders, seven stage heaters, water cooling extracting and condensing steam turbine. The detailed working parameters under turbine maximum continuous rating (TMCR) conditions are shown in Table 7.3. The back-pressure turbine will have the configuration of high pressure, single cylinder, and three stage heaters. The detailed parameters of the back-pressure turbine are shown in Table 7.4.

Table 7.3: Working Parameters of Extracting and Condensing Steam Turbine

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated power (TMCR)</td>
<td>150 MW</td>
</tr>
<tr>
<td>Rated inlet steam flow (TMCR)</td>
<td>500 ton/hr</td>
</tr>
<tr>
<td>Steam pressure at the main stop valve(TMCR)</td>
<td>13.24 MPa (a)</td>
</tr>
<tr>
<td>Steam temperature at the main stop valve</td>
<td>535 °C</td>
</tr>
<tr>
<td>Extraction steam pressure of high-pressure</td>
<td>0.98 MPa(a)</td>
</tr>
<tr>
<td>Extraction steam volume of high pressure</td>
<td>100 ton/hr</td>
</tr>
<tr>
<td>Extraction steam pressure of low-pressure</td>
<td>0.19 MPa(a)</td>
</tr>
<tr>
<td>Extraction steam volume of low pressure</td>
<td>180 ton/hr</td>
</tr>
<tr>
<td>Feed water temperature</td>
<td>235 °C</td>
</tr>
<tr>
<td>Designed back pressure</td>
<td>4.9 kPa (a)</td>
</tr>
<tr>
<td>Regenerative system</td>
<td>7 stages (2 high-pressure heaters, 4 low pressure heaters, 1 deaerator)</td>
</tr>
<tr>
<td>Driving means of feed pump</td>
<td>Electric-driven, hydraulic coupling speed control</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.
Table 7.4: Working Parameters of Back-pressure Steam Turbine

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated power (TMCR)</td>
<td>70 MW</td>
</tr>
<tr>
<td>Rated inlet steam flow(TMCR)</td>
<td>410 ton/hr</td>
</tr>
<tr>
<td>Steam pressure at the main stop valve(TMCR)</td>
<td>8.8 MPa (a)</td>
</tr>
<tr>
<td>Steam temperature at the main stop valve</td>
<td>535 ºC</td>
</tr>
<tr>
<td>Exhausting steam pressure of cylinder</td>
<td>0.4 MPa(a)</td>
</tr>
<tr>
<td>Exhausting steam temperature of cylinder</td>
<td>162 ºC</td>
</tr>
<tr>
<td>Feed water temperature</td>
<td>216 ºC</td>
</tr>
<tr>
<td>Designed back pressure</td>
<td>0.4 MPa(a)</td>
</tr>
<tr>
<td>Regenerative system</td>
<td>3 stages (two high temperature heaters, one deaerator)</td>
</tr>
<tr>
<td>Driving means of feed pump</td>
<td>Electric-driven, hydraulic coupling speed control</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

3. Generator

214. In accordance with the turbine capacity and local electric system requirement, suitable generator is selected. The detailed parameters of the generator are shown in the Table 7.5.

Table 7.5: Working Parameters of Generator

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Three-phase AC synchronous alternator</td>
</tr>
<tr>
<td>Rated power</td>
<td>150 MW (rated power-factor, rated hydrogen pressure)</td>
</tr>
<tr>
<td>Rated power factor</td>
<td>0.85 lagging</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>15.75 kV</td>
</tr>
<tr>
<td>Type of cooling</td>
<td>Stator winding water-cooling, rotor winding and stator-core hydrogen-cooling</td>
</tr>
</tbody>
</table>

Source: TA Team.

G. Thermodynamic System

215. The thermodynamic system primarily involves seven sub-systems including (i) extracting steam system; (ii) water supply system; (iii) condensate system; (iv) drainage and steam releasing system; (v) vacuum-pump system; (vi) auxiliary steam system; and (vii) steam system for district heating. The extracting steam for district heating is adjustable, which is extracted from a middle pressure cylinder. The water supply system is to adopt an individual system. Three motor-driven variable speed feed water pumps are designed for each unit. The condensate system is equipped with four-stage surface type low-pressure heater with full capacity. Under normal operation, condensate water in the high-pressure heater cascades finally into the deaerator, while condensate water in the low-pressure heaters cascades into the expansion tank of drained water from the steam turbine. The vacuum-pumping system of the steam condenser has three 100% capacity water ring vacuum pumps. The start-up steam for the first unit will be supplied by the existing
high-pressure system. It is not necessary to install start-up boilers.

216. The primary heat exchanging station of the district heating system under the Project will provide hot water with supply water temperature of 135°C and return water temperature of 70°C to secondary heat exchanging stations distributed in the urban areas. Main and peak load heat exchangers will be designed for the heat exchanging station. During heating season, through the main heat exchanger, hot water for district heating will be preliminarily heated up from 75°C to 110°C by the steam as the heat source of district heating extracted from the low pressure cylinder of the extracting steam turbine. In case of extreme cold climate which requires higher hot water temperature for district heating than 110°C, the peak load heat exchanger will be put into service to heat up hot water from 110°C to 135°C. The extraction steam from middle pressure cylinder of the turbine will be used as heat source for peak load heat exchanger.

H. Combustion System

217. The combustion system is designed according to properties of coal and firing system. Fuel is fed into the CFB and burned at a relatively low temperature to minimize the production of thermal NOx. For the flue gas desulfurization, fine grain limestone is introduced into the furnace where it is calcined and oxidized.

218. The firing system includes six sub-systems of coal feeding system, limestone system, combustion air system, flue gas system, stack and diesel system. The coal feeding system is designed to distribute coal from a bunker via six conveyers to boiler. The limestone system is to transport limestone from limestone handing house to boiler house by two pneumatic tanks then distribute limestone from limestone silo via two conveyers to boiler. The combustion air system will supply the CFB furnace during start-up and normal operation with required air for sealing, cooling, fluidizing, transportation, and combustion. The purpose of the flue gas system is to transfer heat to the water/steam cycle in the downstream heating surface section and to the primary and secondary air in the tubular air pre-heater. There is one single tube taper stack for three boiler units for Phase I, and one stack for Phase II. Outlet diameter of stacks will be Φ5.5m and the height will be 250 m. The diesel system will be used during start-up and stabilization of combustion (under-30% BMCR-part operation) of the plant CFB boilers.

I. Coal Convey system

219. The coal is unloaded by a “C” type turning forward-backward machine. In addition, due to the extreme cold winter in UB, it is necessary to construct a warm house to defrost the coal. The coal storage capacity is designed to provide more than 30 days usage. The coal conveying system from turning unloading room to coal yard will utilize a belt conveyor. The ferrous metal removing equipment is used for separating magnetic metal substances from coal by using a tramp iron separator with a suspending draper-type and discharging iron automatically.

J. Ash Handling

220. Ash handing system is designed to consider ash quantity produced by each boiler; fly ash conveying system; bottom ash conveying system; and ash transportation off the site. The dust emission concentration of ESP is 50 mg/Nm³. The fly ash content is approximately 50% in total ash while the remaining 50% is bottom ash. The positive pressure dense phase pneumatic ash-handling system is one of the most internationally advanced air transport technologies and is recommended for CHP5 project. The pneumatically fly ash removing system diagram is presented in Appendix 3.
221. The bottom ash handling system will be used to collect and transport bottom ash from the furnace of boiler. The bottom ash from the furnace will be removed continuously by bottom ash coolers, after cooled, then discharged to bottom ash bin through two chain bucket conveyors in series, it will further be transported to the ash disposal yard by truck.

K. Water Treatment Process

222. The proposed water treatment process is designed in terms of water quality; water treatment system for boiler feed water; and auxiliary water treatment processes. The CHP5 will use the existing water source for CHP3. Detailed water quality is presented in Appendix 3. In order to meet the required water quality, the following water treatment system will be used. The underground water will go through the following treatment processes: heating by raw water heater in the turbine shop → raw water tank → raw water pump → mechanical filter with activated carbon bed → anti scaling dosing system → reverse osmoses system with three stages → permeate tank → water pump → mixed ion exchanger → demineralization water tank → demineralization water pump → the main powerhouse. The detailed water treatment system diagram is presented in Appendix 3.

223. Additionally, auxiliary water treatment systems are designed to ensure water quality, including cooling water for auxiliary facilities; treatment system for condensed water; chemical dosing system for feed water; water and steam sampling; integrated treatment station for treating industrial wastewater; water treatment system for cooling of auxiliary machines; drainage system of the plant; make-up water system; and fire sprinkler system.

L. Electrical System

224. In accordance with the perspective of the entire allocation of the power system, the following electrical system was proposed: 220 kV primary voltage interconnection system, the four outgoing lines going back to the 220 kV substation, with the plant equipped with 220 kV power distribution unit. The project will install five 150 MW units and one 70 MW unit, each of which will be connected to 220 kV power system through its own 190 MVA double-winding transformer. A generator circuit breaker (GCB) will be installed on each unit between its generator outlet terminals and the generator transformer. The detailed grid connection system diagram is shown in the drawing section of Appendix 3.

225. The rated capacity of transformers will be selected according to the average temperature rise of transformer winding in normal ambient temperature, not exceeding 65°C after the maximum continuous volume of generators deducting the service power calculated capacity of units. According to the installation program, the rated output of the CHP5 is designed to be 820 MW on the basis of 5x150 MW turbines plus 1x70 MW backpressure turbine, in which the rated capacity of the main transformer is 190 MVA, and adopts three-phase transformers.

226. The main transformers, high-voltage local transformers, high-voltage start/spare transformers and other electric facilities will be arranged behind row A of the power house. The project will adopt a 220V DC system. One bank of batteries and two sets of 100% high frequency switch rectifying charging equipment (battery charger) will be provided for each unit. The electrical system control and protection will be designed for the project involving relay protection and security system.

227. The communication within the plant includes: production management communication system, production dispatching communication system (including production dispatching system, coal handling amplification/paging system) and wireless talk back communication system. The three parts are mutually back-upped and complemented, so as to form a safe and reliable plant wide communication network of administration, production dispatching, and overhaul maintenance.
228. A 220 kV circuit is adopted from the CHP5 plant to CHP4/Erdenet. Each line is to be equipped with two sets of full line and quick action main protection as well as back-up function. Both sets adopt Optical Ground Wire (OPGW) fiber channel and dedicated optical fiber core. The distance skip and main protection share a common tunnel.

229. Each circuit breaker will have a protection screen. Each 220 kV bus is equipped with two sets of microcomputer bus protection. One fault recorder device is configured for the 220 kV wayside housing. An information substation for protection and fault recorder is designed for the power plant, which can communicate with the dispatching center. The security and stability control device needs to be studied separately. The place for a control device screen will be reserved.

230. The CHP5 plant will also be under dispatching management by NDC. The tele-control system will be designed as a remote transmission unit.

M. Plant Control System

231. The control system of the CHP5 plant should be completely integrated based on modern distributed control systems (DCS) which will provide the safe, reliable, and efficient operation of all units and the main station/common plant. The control system will include the coordinated integrated control of the turbine and boiler, boiler controls, boiler auxiliaries controls, turbine controls, turbine auxiliary controls, boiler and turbine protection, electrical system controls, ash and coal plant controls, flue gas desulfurization, water treatment plant controls, distribution heating system, and other common/station plant control systems.

232. The plant will be controlled and monitored from a centralized plant control room (PCR) located in the control building. The centralized PCR will be staffed 24 hours per day.

233. Plant control system should be equipped with training simulators for training operators and new staff. Flue gas monitoring system will be connected to the DCS with adequate data bus or interface and make available to continuously monitor and create data base measurement. The boiler soot-blowing control system will be interfaced with DCS. Turbine manufacturer will provide Digital Elector-Hydraulic (DEH) control cabinet, control oil system, local instrument and control equipment for turbine control and it will be interfaced with the DCS. The turbine by-pass system control functions will be implemented in the DCS. The emergency trip system (ETS) is a part of DCS. The logic system performing the safety functions of protection system for the plant major equipment like boiler, turbine, and generator. The turbine supervisor instrument (TSI) is located in the electronic equipment room. TSI will monitor vibration, thrust bearing axial displacement, eccentricity, speed monitor, and differential expansion, etc. Additionally, the Electric Control System (ECS); Sequence of Event (SOE) Recording System; Limestone Handling Control System; and flying ash and bottom ash handling control system should be included in the design.

234. The DCS systems will provide comprehensive process monitoring, control functions, displays, alarming, calculations, data logging, data display, data storage and retrieval, and other functions for each generating unit and its associated auxiliaries and all station plant described above. Additionally, the control processors subsystem; system redundancy requirements; data highways; bridges and gateways; functional requirements and cross monitoring; DCS to other control systems; information system networks and Ethernet bridges; installed and system expansion requirements; and spare inputs and outputs are to be considered in the design of the plant control system. Detailed description is presented in Appendix 3 of this report.

N. Civil Engineering

235. The three-row layout of the turbine room, combined deaerator and coal storage room and boiler room is designed for the main power house. The central control room is located
between the turbine room and the boiler room. The operating floor for the boiler room is located at level 9 m and one elevator for each boiler is installed for transportation of goods and people. Transportation within the main power house including horizontal and vertical will be designed to ensure well organized operation within the main power house.

236. In addition, fire prevention and evacuation; sanitary facilities; water prevention and drainage of floors and roofs; lighting and ventilation; heat supply; decoration and finishing requirements; and auxiliary buildings need to be considered in the designs.

237. Civil engineering designs will be completed in full consideration of the major technical parameters; safety standards; seismic fortification intensity; flue gas pipe and chimney; coal yard, transfer station and conveying corridor; bottom ash storage and fly ash silo; water treatment buildings; warehouse, mechanical workshop, as well as office and complex and guard house will be designed. Detailed design Principle and requirements are described in Appendix 3 of this report.

O. Water Supply and Drainage System, Cooling Facility

238. Water supply and drainage system and cooling facility will be designed in relation to water source; circulating water system; make-up water system; service water system; water supply and drainage of the entire plant; hydraulic design; and water conservation measures. Two circulating pumps will be designed for each turbine and each pump will handle 50% of designed circulating flow rate for each turbine. A total of ten circulating pumps will be installed, of which six pumps will be installed during Phase I and four additional pumps for Phase II. Two cooling tower will be constructed for Phase I, with 4,500 m² cooling surface each. One additional cooling tower will be constructed for Phase II, with 6,000 m² cooling surface.

239. The water will be refilled for cooling tower make-up water, boiler and heating system, industry water system, domestic water system, and fire fighting water system. The water consumption will be 1,456 m³/hr in summer and 1,344 m³/hr in winter. The annual total water consumption will be 8.1 million m³/a.

240. The existing water supply system can serve as the water source of the industrial service water system. Water for chemical water treatment and make up water for cooling tower are provided by the service water pump that meets the requirement of the CHP5. Domestic water supply system is fed from city water supply system. The detailed water treatment system diagram is shown in the drawing section of Appendix 3. Water supply and drainage systems include: domestic water supply; storm water drainage, domestic sewage, wastewater drainage; and domestic sewage treatment.

241. A comprehensive water pump house will be constructed. The domestic sewage treatment station includes two wastewater treatment facilities, one wastewater regulating tank, and one clean water tank. The system should also include the wastewater treatment facility; the clean water tank; the oily wastewater treatment station; oil-water separator room; oily wastewater regulating tank; and two industrial fire cisterns with a capacity of 1000 m³, a reclaimed water tank with a capacity of 400 m³, a domestic water tank with a capacity of 200 m³ and two oil tanks against accidents with capacity of 100 m³. All facilities are designed to be cast-in-place reinforced concrete underground structures.

242. The effective water conservation measures will be taken including installation of dehydrator; recycling of treated wastewater; dry mechanical slag removal; use of pneumatic conveyors; domestic sewage; coal contained wastewater; and management of domestic water usage.

P. Fire Fighting System

243. The fire fighting system includes water fire fighting system, gas fire fighting system,
foam fire fighting system as well as fire extinguishers installations, construction of fire fighting pond, fire pumps and fire pipeline network. Water fire fighting system is responsible for the fire fighting of the main plant, auxiliary and associated buildings, oil tank area, as well as fire fighting water of cooling water and transformer water spray, automatic spraying or spraying system of the equipment in the main plant, automatic spraying system of coal transport system.

Q. Control of PM, SO$_2$ and NO$_x$ Emissions

1. Electrostatic Precipitator

244. Each generator unit will be provided with an ESP with parallel gas paths. Each path will consist of four electric fields in a series for the collection of fly ash. The ESPs will have a dust collection efficiency of not less than 99.6%, while firing coal with the ash content of 10%.

245. ESP removes PM from the flue gas stream. Six activities typically take place: i) Ionization - charging of particles; ii) Migration - transporting the charged particles to the collecting surfaces; iii) Collection - precipitation of the charged particles onto the collecting surfaces; iv) Charge Dissipation - neutralizing the charged particles on the collecting surfaces; v) Particle Dislodging - removing the particles from the collecting surface to the hopper; and vi) Particle Removal - conveying the particles from the hopper to a disposal point.

246. Designing a precipitator for optimum performance requires proper sizing of the precipitator in addition to optimizing precipitator efficiency. Precipitator performance depends on its size and collecting efficiency. Important parameters include the collecting area and the gas volume to be treated. Other key factors in precipitator performance include the electrical power input and dust chemistry.

2. SO$_2$ Removal Facility

247. CFB boilers will be utilized for the CHP5 plant. CFB boiler has been widely adopted in power plants for its characteristics of saving coal, high efficiency and high reliability. It is well known that desulfurization in the boiler using limestone is an outstanding advantage of a CFB boiler. Generally, the combustion temperature of CFB boiler keeps between 800°C–900°C and it is the right temperature range for the activity of limestone decomposing into lime. The desulphurization efficiency is also high at this temperature range. Therefore, with appropriate Ca/S and particle size of limestone, the desulphurization efficiency of 80% or more can be reached when Ca/S ratio is about 2.0. Thus a CFB boiler is comparatively fit for middle and low sulfur fuel. Limestone powder is utilized as the desulfurization absorbent. The quality requirements of limestone are: CaO>50%; MgO≤2%, SiO$_2$≤2%, fineness is: 250 mesh, sieving residue <10%. The annual limestone consumption is estimated at 152,000 tons.

3. NO$_x$ Control Equipment

248. In addition to low NO$_x$ generation from CFB technology, selective non-catalytic reduction (SNCR) system will also be used for additional control of NO$_x$. A reagent is injected into the flue gas in the furnace within an appropriate temperature window. Emissions of NO$_x$ can be reduced by 30% to 50%. The NO$_x$ and reagent (urea was proposed) react to form nitrogen and water. A typical SNCR system consists of reagent storage, multi-level reagent-injection equipment, and associated control instrumentation. The SNCR reagent storage and handling systems are similar to those for SCR systems. However, because of higher stoichiometric ratios, both the ammonia and urea SNCR processes require three or four times as much reagent as SCR systems to achieve similar NO$_x$ reductions.

249. The reagent injection system must be able to place the reagent where it is most effective within the boiler because NO$_x$ distribution varies within the cross section. An injection system that has too few injection control points or injects a uniform amount of
ammonia across the entire section of the boiler will almost certainly lead to a poor distribution ratio and high ammonia slip. Distribution of the reagent can be especially difficult in larger coal-fired boilers because of the long injection distance required to cover the relatively large cross-section of the boiler. Multiple layers of reagent injection as well as individual injection zones in cross-section of each injection level are commonly used to follow the temperature changes caused by boiler load changes.

R. Beneficial Utilization of Ash

250. Fly ash generated during power generation in the coal-fired power plant is one of the solid waste sources. It is removed from the plant exhaust gases primarily by ESP. Physically, fly ash is a very fine, powdery material, composed mostly of silica nearly all particles are spherical in shape. Fly ash is a pozzolan, a siliceous material which in the presence of water will react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. Because of its spherical shape and pozzolanic properties, fly ash is useful in cement and concrete applications, such as enhancing workability, increasing penetration-proof quality, reducing creep and long-term high strength after mixing coal ash. It has been widely applied as building materials in many countries. Using coal ash can also bring rather considerable financial benefits. The spherical shape and particle size distribution of fly ash also make it a good mineral filler in hot mix asphalt applications and improve the fluidity of flowable fill and grout when it is used for those applications. The dry ash application research has been successful in recent years.

251. Bottom ash is agglomerated ash particles, formed in CFB furnaces, which are too large to be carried in the flue gases and impinge on the furnace walls or fall through open grates to an ash hopper at the bottom of the furnace. Physically, bottom ash is typically grey to black in color, is quite angular, and has a porous surface structure. Bottom ash is coarse, with grain sizes spanning from fine sand to fine gravel.

252. Bottom ash can be used as a replacement for aggregate and is usually sufficiently well-graded in size to avoid the need for blending with other fine aggregates to meet gradation requirements. The porous surface structure of bottom ash particles make this material less durable than conventional aggregates and better suited for use in base course and shoulder mixtures or in cold mix applications, as opposed to wearing surface mixtures. This porous surface structure also makes this material lighter than conventional aggregate and useful in lightweight concrete applications. More advantageously, the bottom ash from CFB of the CHP5 will be more desirable for cements and the like construction materials, due to containing gypsum that is a beneficial additive to improve the function of cements and the like.

253. CHP5 will be located in the urban area of UB city, which provides a good opportunity for comprehensive ash utilization. At the meeting with related construction materials agencies and manufacturers in UB, the TA Team was informed that the ash generated from the power plant is desirable for construction materials sector. Due to local unavailability of ash most of which is handled through wet process, some of the local manufacturers have to import ash from adjacent countries for producing construction materials. The project’s ash design adopts ash dividing and dry ash dry emissions system, which provides possibilities for ash comprehensive utilization in the future. The application prospects are vast. However, the unclear radiation level of the ash might limit the utilization of ash to certain extent.

254. In order to rationally evaluate the radiation level of the ash and suitability of ash in construction materials, the consultants engaged the Radiation Lab of the University of Science and Technology. More than 38 coal, ash and slag samples were tested and the test results along with the radiation standards are summarized in the Table 7.6. The Mongolian national radioactivity standards are for radium equivalent (Bq/kg): <370 for living house and public service building; < 740 for industrial building and road construction.
Table 7.6: Radioactivity of Coal, Ash and Other Construction Materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Sample ID</th>
<th>Isotope Activity (Bq/kg)</th>
<th>Radium Equivalent (Bq/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$^{226}$Ra</td>
<td>$^{232}$Th</td>
</tr>
<tr>
<td>1</td>
<td>Baganuur coal</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Shivee-Ovoo coal</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>CHP3 ash and slag avg</td>
<td>135</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>CHP4 Baganuur ash</td>
<td>168</td>
<td>61</td>
</tr>
<tr>
<td>5</td>
<td>CHP4 Shivee-Ovoo ash</td>
<td>267</td>
<td>142</td>
</tr>
<tr>
<td>6</td>
<td>CHP4 Baganuur slag</td>
<td>145</td>
<td>39</td>
</tr>
<tr>
<td>7</td>
<td>CHP4 Shivee-Ovoo slag</td>
<td>236</td>
<td>104</td>
</tr>
<tr>
<td>8</td>
<td>Sand</td>
<td>23.3</td>
<td>20.5</td>
</tr>
<tr>
<td>9</td>
<td>Gravel</td>
<td>21.7</td>
<td>17.0</td>
</tr>
<tr>
<td>10</td>
<td>Limestone</td>
<td>23.2</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Source: National University of Mongolia and TA Team estimate.

255. An average value as 228 Bq/kg of radium equivalent for natural radioactive isotopes in ash and slag sample from boiler in TPP-3 and TPP-4 where Baganuur coal dominantly burning is 38% lower than the permissible limits (370 Bq/kg) in purpose of that utilization of building material for public and plant building. Furthermore, we reached up an initial conclusion that there is a possibility to use as a building material mixing with waste ash and other low radioactive components.

256. An average value as 468 Bq/kg of radium equivalent for natural radioactive isotopes in ash sample from boiler, where Shivee-Ovoo coal burning, in TPP-4 is 27% higher than the permissible limits in purpose of that utilization of building material for public and plant building. Hence ash of Shivee-Ovoo coal mine, instant of its utilization of plant building, is possible to use as mixing with other raw material for which reducing radiation as low as reasonably achieve, to public and plant building.

257. However, average value as 394 Bq/kg of radium equivalent for natural radioactive isotopes in slag sample of Shivee-Ovoo is 7 % higher than the permissible limits in purpose of that utilization of building material for public and plant building. Hence, instant of its utilization in plant building, slag of Shivee-Ovoo coal is possible to use as mixing with other raw material, reducing radiation as low as reasonably achieve, to public and plant building.

258. In order to ensure the ash can be used for building material, the National University of Mongolia (NUM) and Mongolia Building Material Manufacturers Association (BMMA) performed laboratory tests on the building material made of ash and other raw material. The results are shown in the following Table 7.7.
### Table 7.7: Radioactivity Test Results of Building Material and Ash Additive

<table>
<thead>
<tr>
<th>Name of material, composition /kg/, other characteristics, 1m³</th>
<th>Volume of material in m³, kg/m³</th>
<th>Hardness characteristic, kg/cm²</th>
<th>Share of ash in total dry weight</th>
<th>Radium equivalent, Bq/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ready mix concrete M250</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel /5-20/ / Sand / Cement / Ash / Water</td>
<td>1290</td>
<td>378</td>
<td>330</td>
<td>190</td>
</tr>
<tr>
<td><strong>foam concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>foam / Cement / Ash / Water</td>
<td>1</td>
<td>340</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td><strong>Slag concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slag / Sand / Cement / Water</td>
<td>460</td>
<td>391</td>
<td>326</td>
<td>220</td>
</tr>
<tr>
<td><strong>Expanded aleurolite concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel /5-20/ / aleurolite / Cement / Ash / Water</td>
<td>830</td>
<td>220</td>
<td>200</td>
<td>160</td>
</tr>
<tr>
<td><strong>Polystirol concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polystirol, L / Cement / Ash / Water</td>
<td>1100</td>
<td>250</td>
<td>250</td>
<td>175</td>
</tr>
<tr>
<td><strong>Expanded ceramsite concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel /5-20/ / of ceramsite / Cement / Ash / Water</td>
<td>620</td>
<td>220</td>
<td>200</td>
<td>190</td>
</tr>
<tr>
<td><strong>Composite structural concrete</strong> /polystirol, aleurolite, ash/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polystirol, L / Aleurolite / Cement / Ash / Glue / Water</td>
<td>500</td>
<td>300</td>
<td>300</td>
<td>154</td>
</tr>
<tr>
<td><strong>Composite structural concrete</strong> /pärítá, ceramsite, ash/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perlite / Ceramsite / Cement / Ash / Water</td>
<td>45</td>
<td>152</td>
<td>180</td>
<td>575</td>
</tr>
<tr>
<td><strong>Composite structural concrete</strong> /wood sawdust, ceramsite, ash/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood sawdust / Ceramsite / Cement / Ash / Glue / Water</td>
<td>100</td>
<td>345</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td><strong>Perlite concrete</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
259. Based on the above results, it’s concluded that the ash from the Baganuur coal mines can be used as construction materials for any purposes without restrictions. The ash from Shivee-Ovoo coal mine can be mixed with other construction materials and then used as construction material.

S. Ash Yard

260. The ash will be beneficially used as construction material, but a tentative or emergency ash yard should be designed for CHP5. The ash yard is located 0.5 km away from the west side of the CHP5. Trucks will be used for transporting ash. The external ash transport road will be a concrete paved road with the width of 7 m and sub-grade with the width of 8.5 m. The internal ash transport road will be of clay-bound macadam pavement with the length of 0.5 km, paved width of 6.5 m and sub-grade width of 8 m. In addition, ash dam and drainage measures; seepage control; ash yard O&M; and environmental protection measures should be fully considered in the design of the ash yard.

T. Heating Network

261. From hydraulic balance and least cost perspectives, heat source should be constructed close enough to heating area center. The TA team conducted a detailed hydraulic calculation on the index primary circuit to describe the feasibility and reliability of the hydraulic system of the network that will be served by CHP5. The heating network assessment focuses on three major areas: (i) proposed pipeline and operational parameters; (ii) hydraulic calculation and pressure curve; and (iii) hydraulic balance to demonstrate that the Project is technically justified for its functioning heating network system.

1. Proposed Heating Pipeline System and Operation Parameters

a. Proposed Pipeline System

262. Pre-insulation bonded pipe is by far the most commonly used technology for both new district heating and cooling systems as well as for rehabilitation of existing systems. Steel pipes, insulation materials made of polyurethane foam (PUR), and high density polyethylene (HDPE) are bonded into one piece in a sandwich-like structure. Compared to on-site insulation pipe buried in a tunnel, a direct-buried pre-insulation bonded pipe has many advantages, such as lower capital cost; reduced heat losses; improved energy efficiency; better anti-corrosive and insulation performance; longer service life; limited land acquisition requirement; and shorter installation cycles, which are conducive to environmental protection and offer great conditions for construction of municipal facilities.

b. Working Parameters

263. Working Temperatures. Upon completion of the CHP5, about 820 MW of power generation capacity and 1,281 MWt (1,101Gcal/hr) of heating capacity are expected. The
calculation suggests that the 135°C feed water temperature and 70°C return water temperature are suitable for the heating system of CHP5.

264. **Heating Capacity and Flow Rate.** The total heating demand of the CHP5 is estimated to be 1,281 MWt (1,101 Gcal/hr). The size of the new heating pipeline is to be designed to accommodate a heating capacity of 506 MWt (435 Gcal/hr), and other heating capacity will be covered by the existing heating network. The flow rate of the main pipeline from the CHP5 is calculated at 6,690 ton/hr.

265. **Working Pressure.** In line with international design specification, a nominal pressure of 1.6 MPa is selected for the primary circuit of the district heating system. To best fit the existing heating system, the nominal pressure of the primary circuit to be connected with the CHP5 should be selected at 1.6 MPa.

c. **Proposed Route of Primary Heating Pipeline**

266. To reduce the capital cost and minimize potential social and environmental impacts likely brought about by the Project, the TA Team recommends that the existing pipeline system of CHP3 is fully utilized for CHP5 after these aged, deteriorated, and unreliable pipelines are upgraded. On top of that, an additional new primary circuit is to be installed to form the new pipeline system for CHP5.

267. The TA Team conducted a preliminary survey and identified a new pipeline route suitable for CHP5. The new route starts at the industrial district area near CHP3, via 5A Primary Pipeline, the EA building, Dundgol River Dam, and Peace Bridge, then returns back to Sun Road and branches at Narantuul Market, being hooked up to the existing pipelines. The heating circuit is to be divided into two branch networks at Narantuul Market: one is to be connected with customers in the Amgalan area and another is to connect customers residing in the Altan-Ulgii area and the further east area of UB. The index circuit is designed at 16.7 km in length. The detailed route of the index circuit is shown in **Figure 7.1**. The detailed route of the pipeline and locations of main substations are shown in **Appendix 3** of this report.

**Figure 7.1: Heating Network Route**

![Figure 7.1: Heating Network Route](image)

2. **Hydraulic Calculation**

268. Hydraulic resistance of a pipeline system normally consists of friction resistance and local resistance. The friction resistance and total hydraulic resistance of main pipeline are
calculated in accordance with the formula shown in Appendix 3. The hydraulic calculation was conducted for two scenarios. Scenario 1: maximum diameter of the network is designed as DN1200; and Scenario 2: maximum diameter of the network is designed as DN1000.

3. Hydraulic Balance

269. Hydraulic balance is one of the major concerns in designing a district heating system to accommodate huge amounts of heating capacities. Under the CHP3 site option, a well-maintained hydraulic balance could be achieved through accurate hydraulic balance calculation, installation of functioning hydraulic balance valves, effective control and monitoring system, and effective operation and maintenance implementation.

270. Hydraulic balance includes two parts: initial or static balance and dynamic balance. The initial or static balance means that the heating system reaches a stable hydraulic balance under designed working conditions. The static balance is maintained through proper pipeline system design and systematic adjustment manually (initial state) or automatically. The static balance is relatively easily maintained compared to the dynamic balance.

271. Dynamic balance relates to the control and regulation of the heating system, which is very important in achieving high energy efficiency, maintaining a stable and reliable heating system, and ensuring a quality heating service. Variable flow rate control technology has been widely applied in the primary heating system, in which hydraulic balance varies with flow rate changes. It is nearly impossible to maintain a sound dynamic balance without automatic control and regulation system being implemented. As the technology develops in hydraulic balance valve and control and monitoring system, the hydraulic system is regulated to continuously accommodate the heat demand variations with outdoor temperature, so as to maintain a dynamic balance. Nowadays, the modern district heating system with effective control system could maintain a sound hydraulic balance.

4. Conclusion

272. Based on the above analysis, it is concluded that the hydraulic circulation can be established through a proper engineering design of the pumping and pipeline systems and that the hydraulic balance can be maintained through the installation of effective balance valves and a control and monitoring system to ensure a stable and reliable heating system.

U. Human Resources

273. The CHP5 power plant should be designed with appropriate staff numbers. A standardized staffing supervision procedure, an efficient and well-structured organization with clear definition of departmental and post responsibilities and an equipment overhaul system must be considered when considering human resources need at the plant. The staff numbers of the entire plant is recommended to be 648, including preparation staff. Detailed staffing plan is provided in Appendix 3 of this report.

V. Safety and Occupational Health

274. Safety will involve fire, explosion, electric shock, mechanical injury and fall hazard. Safety measures shall be taken into consideration to ensure safer construction and operation of the Project. Fire prevention and anti-explosion measures will be taken in full consideration of fire rating of buildings; fire distance of buildings; fire prevention of main power house; safe transportation inside the main plant; access roads of the entire plant; fire prevention of the entire plant; fire prevention of oil system; and fire prevention of electric accessory and cables.

275. Statistic data shows that most of casualty accidents are caused by mechanical injury during construction and maintenance. Therefore, the staff should follow safety procedures...
during construction, operation and overhaul. Other safety precautions shall include device anticorrosion; pipe anticorrosion; floor and drainage ditch anticorrosion; crane inspection/repair facilities, platforms and Galleries’ settings; safety signs and colors; and safety lighting, etc.

276. Occupational health is one of the important areas to ensure smooth operation of the Project. The harmful occupational factors should be identified to develop effective occupational health prevention measures. The physical factors might include dust; noise and vibration; high temperature and humidity. The chemical factors might include poisonous and harmful gas during operation; and SF₆ gas and fire resistant oil and other substances, etc.

277. Effective occupational health prevention measures will be taken to prevent dust; defense gases and prevent chemical related injuries. Additionally, effective measures will also be taken to protect noise and vibration; prevent freezing and heatstroke, etc.

W. Energy Conservation

278. Energy conservation measures involve three aspects: (i) energy consumption of major and auxiliary equipment; (ii) improvement of operating efficiencies; and (iii) new technology applications. The energy-saving measures will include but not limited to: (i) optimization of technology system designs; (ii) equipment selection; (iii) energy conservation in buildings, for example, lighting; insulation; and material utilization. Detailed energy conservation measures are described in Appendix 3 of this report.
VIII. ENVIRONMENTAL IMPACT ASSESSMENT

279. This section describes the results of environment impact assessment (EIA) of the CHP5 Project, including objectives of the EIA process, domestic and international legal and administrative framework for EIA study, environmental baseline in UB area, analysis of environmental impacts and proposed mitigation measures, and estimated emission reduction, coal savings, and other environmental benefits, etc. The full EIA report is attached to this report as Appendix 4.

A. Scope and Objectives of EIA

280. The proposed CHP5 Project may cause positive and negative, short-term and long-term, direct and indirect, and reversible and irreversible impacts on the physical and ecological environment. During the EIA study, there is a need to identify environmental benefits and adverse impacts of the Project quantitatively and develop appropriate mitigation measures for i) avoiding or mitigating the impacts; ii) compensating the impacts; and iii) enhancing the environmental benefits and improvement.

281. The emphasis during the EIA study is to facilitate decision-making and to ensure that the Project options are environmentally sound and sustainable and contribute to the development and enhancement of environmental assets in UB.

282. The EIA’s main objective is to determine the magnitude of potential impacts due to proposed CHP5 Plant and to suggest most suitable control measures with optimum cost benefits. An environmental management plan (EMP) has been prepared after detailed studies of all existing environmental attributes in the Project influence area. It includes the outcome of detailed discussions held between environmental consultants and the engineering consultants for finalization of the feasibility study (FS), considering improvement of power supply and heating supply in UB with minimal costing and suitable environmental pollution control measures. The broad objectives of the EIA study are to: i) estimate positive impacts and environmental benefits; ii) assess environmental status in the Project and its surrounding areas; iii) identify and assess environmental impacts of the proposed CHP5 on natural, physical, and socio-economic environments during design, construction, and operation phases; iv) identify areas and aspects that are environmentally or socio-economically significant; v) develop mitigation measures broadly ensuring that the environment and residents are least affected, and develop cost-effective and implementable measures for mitigation of adverse environmental impacts, if identified; vi) determine the magnitude of environmental impacts so that due consideration be given to these during planning/design, construction, and operation phases of the CHP5; and vii) develop a practical and implementable EMP for mitigation of adverse environmental impacts and monitoring of mitigation measures during Project construction and operation stages.

B. Environmental Impacts Assessment Report

283. The EIA Report has been prepared in accordance with the requirements of ADB’s Safeguard Policy Statement (SPS, 2009) and the Mongolia Environmental Impact Assessment Law (1998 and subsequent amendments), and is based on the feasibility study of the Project, site inspections, other technical reports, and public/stakeholder consultations conducted by the TA Team.

284. The EIA provides an assessment of potential environmental impacts and risks associated with the proposed CHP5 Project and includes i) a summary of the Mongolian domestic and international applicable policies, standards, and guidelines; ii) description of the Project; iii) description of the environment (baseline); iv) alternative analysis; v) anticipated
environmental impacts and mitigation measures during construction and operation; vi) economic analysis; vii) information disclosure, consultation, and participation; viii) grievance redress mechanism; ix) EMP, including implementation schedule and performance indicators; and x) conclusion and recommendations.

285. The ADB SPS provides the primary basis for this EIA. The SPS consists of three operational policies on the environment, indigenous peoples, and involuntary resettlement. With respect to environment, these policies are accompanied by ADB Operations Manual on Environmental Consideration on ADB Operations (2010). The policy promotes international good practice as reflected in internationally recognized standards such as the World Bank Group’s Environmental, Health and Safety Guidelines.

C. Environmental Baseline of the Project Area

286. Water Resources. Mongolia is an arid and semi-arid country with annual average precipitation of 250 mm, ranging from 400 mm in the north to less than 100 mm in the southern Gobi region. Approximately 90.1% of it evaporates, leaving only 9.9% to form surface runoff. Of this remaining 9.9%, 37% infiltrates into the soil while 63% turns into surface runoff. Almost 95% of the surface runoff component flows out of the country. Consequently, only 6% of annual precipitation is transformed into available water resources in surface water bodies. Water resources of Mongolia are highly vulnerable to climatic conditions and are limited and unevenly distributed within the country. There are three main hydrological basins, including the Arctic and Pacific Oceans’ Basins and Central Asian Endo-Archaic Basin. Rainfall is the principal source of water for the rivers of the region, while water from melting snow makes up 15-20% of the annual runoff. About two-thirds of the surface runoff leaves Mongolia. Total water resources of Mongolia are estimated to be 610 km³. Twenty percent of the country’s water consumption originates from surface water and 80% from groundwater sources. Groundwater is currently the main source of supply for household and drinking use, watering points for pastures, and industrial consumption.

287. The water quality is suffering in both the urban and suburb districts of UB. With the shift to a market-based economy, many small businesses are springing up and are discharging their wastewaters directly into the Tuul River and its tributaries. These new industries are difficult to supervise and have resulted in enforcement problems. Also, some ger districts have been built on low-lying land, resulting in groundwater contamination from latrines. At present, surface water pollution is an environmental issue. Both the Project FS and EIA have considered these issues and recommended suitable measures to avoid the problems. The water quality of the Tuul River is shown in the EIA Report (Appendix 4).

288. Ambient Air Quality. UB is situated in an area that is surrounded mountains, including Chingeltei Mountain (northern side), Bogd Mountain (southern side), Songinokhairkhan Mountain (western side), and Bayzurk Mountain (eastern side). Therefore, a layer of smoke usually covers the city due to bad air dispersion characteristics.

289. Severe air pollution is a major issue in UB, particularly in the winter due to pollution from coal-fired stoves in the ger districts in winter and sandstorms in spring. There is also growing air pollution from an increasing amount of vehicle traffic and from individual HOBs. Air pollution from industries was said to be negligible and the factories have had more or less emission control devices in the last ten years. Official documents say that 40% of the air pollution is from the stoves used in the ger area, 30% is from vehicle emission, 20% is from the HOBs, and 10% is from the existing coal-fired CHP plants. The ash in the open pond was stirred to causes disaster nearby the UB during the windy days.

290. According to the World Bank’s joint research with the National University of Mongolia and the Norwegian Air Research Institute, one of the worst sources of the pollution is dust. The dust originates from the ger heating stoves, the desert, the dry ground condition, and the ash ponds from the existing CHP plants. With few trees and hardly any parkland in UB, the
regularity and severity of windstorms in the city is increasing, creating dangerous levels of airborne dust. Strong winds, particularly in spring, also allow dust from the Gobi desert and other arid regions of Mongolia to reach the city.

291. **Acoustic Environment.** The noise sources in UB are mainly from travelling motor vehicles, ongoing construction, and commercial activities. The Mongolian national noise standard (MNS-4585-2007) requires below 60dB(A) during daytime and below 45dB(A) at night. These values, given in dBA, approximate the way the human ear perceives airborne sound. A noise monitoring has been carried out along the boundary of the proposed Project area during the TA Team’ EIA Study to establish a baseline for the analysis of the potential additional noise that will be generated by the construction as well as the operational phase of the CHP5 Project. Samplings have been carried out in good weather with light wind, as indicated in the EIA Report. The monitoring result show that the noise levels at some monitoring sites during daytimes exceeded the national standard.

D. Applicable Domestic International Laws, Policies and Standards

292. **Domestic Environmental Laws, Policies and Standards.** Mongolia has enacted a comprehensive policy and legal framework for environmental assessment and management. The country has policies, legislation, and strategies in place to manage the protected estate, to satisfy its international obligations, and to protect the quality of the environment for the health and well-being of its citizens. The hierarchy of policies and legislative provisions for environmental management in Mongolia comprises five layers, ranging from the Constitution to international treaties and to environment and resources protection laws.

293. The main domestic environmental laws, policies, and regulations are: i) National Environmental Action Plan (1996); ii) the State Environmental Policy (1997); iii) the National Action Plan for Combat Desertification; iv) the Biodiversity Conservation Action Plan; and v) the National Action Plan for Protected Areas, all of which were developed under the Ministry of Nature Environment and Tourism (MNET) auspices, as well as the Mongolian Action Program for the 21st Century with subordinated aimag development plans developed by the National Council for Sustainable Development. The National Environmental Action Plan was updated in 2000 and the National Action Plan for Climate Change was added in the same year. Several program documents (e.g. National Water Program, National Forestry Program, Program of Protection of Air, Environmental Education, Special Protected Areas, and Protection of Ozone Layer) were also completed at the turn of the decade. EIA state policy was in place in 1998. In addition, other guidance documents with important environmental repercussions were developed under the auspices of other ministries. These include the Roads Master Plan, the Power Sector Master Plan, the Tourism Master Plan, and the Renewable Energy Master Plan. Other documents, such as the annual Human Development Reports, have increasingly incorporated environmental aspects.

294. A fundamental principle of the Mongolian environmental policy is that economic development must be in harmony with the extraction and utilization of natural resources and that air, water, and soil pollution will be controlled. In April 1996, Mongolia’s National Council for Sustainable Development was established to manage and organize activities related to sustainable development. The country’s strategy is designed for environmentally friendly, economically stable and socially wealthy development, which emphasizes people as the determining factor for long-term sustainable development.

295. Mongolia’s EIA requirements outline environmental protection, the prevention of ecological imbalance, the regulation of natural resource use, the assessment of environmental impacts of projects, and decision-making procedures regarding Project implementation. The terms of the law apply to all new projects, as well as rehabilitation and expansion of existing industrial, service, or construction activities and projects that use natural resources. The planned activity’s type and size define which responsibility may be
MNET or and which may be UB and aimag (local) government.

296. There are two types of EIAs defined in the EIA Law: General EIA and Detailed EIA. To initiate a General EIA, the Project implementer submits a brief description of the Project, including the feasibility study, technical details, drawings, and other information to MNET (or aimag government). The General EIA may lead to one of four conclusions: (i) no Detailed EIA is necessary; (ii) the Project may be completed pursuant to specific conditions; (iii) a Detailed EIA is necessary; or (iv) cancellation of the Project.

297. The scope of the Detailed EIA is defined during the General EIA process by the MNET's experts. The Detailed EIA report must be produced by an authorized Mongolian company which is approved by the MNET by means of a special procedure. The developer of the Detailed EIA should submit it to the MNET. An expert of the organizations who were involved in conducting the General EIA should make a review of the Detailed EIA within 18 days and present it to MNET. Based on the conclusion of the expert, the MNET makes a decision about approval or disapproval of the Project.

298. **ADB's EIA Policies and Requirements.** The major applicable ADB policies, regulations, requirements, and procedures for the EIA are detailed in *Environmental Assessment Guidelines of ADB* (2003) and *Safeguard Policy Statement* (SPS, June 2009). The SPS provides a basis for EIA process and contents. With respect to the environment, these policies are accompanied by *ADB Operations Manual's Bank Policy* (OM F1, 2010). The policy promotes international good practices as reflected in internationally recognized standards such as the World Bank Group's *Environmental, Health and Safety Guidelines*.

299. **Complying with ADB's SPS.** The purpose of the SPS is to establish an environmental review process to ensure that projects undertaken as part of programs funded under ADB loans are environmentally sound, are designed to operate in compliance with applicable regulatory requirements, and are not likely to cause significant environmental, health, or safety hazards.

300. The SPS is a set of operational policies that seek to avoid, minimize, or mitigate adverse environmental and social impacts, including protecting the rights of those likely to be adversely affected or marginalized by the development process.

301. **The World Bank Group's EHS Guidelines** are technical reference documents with general and industry-specific examples of Good International Industry Practice. The EHS Guidelines are provided in a general set in four major categories, supplemented by relevant industry sector-specific EHS guidelines. For the Project, the General EHS Guidelines includes four aspects of: i) environment; ii) occupational health and safety; iii) community health and safety; and iv) construction and decommissioning.

**E. Expected Environmental Benefits**

302. The proposed CHP5 will significantly improve UB’s air quality by using an environmentally friendly CHP technology with advanced emission control equipment that consumes less coal and emit fewer pollutants to replace outdated CHP2 and CHP3 plants, as well as hundreds of small, inefficient HOBs and thousands of space and water heaters. Water and soil pollution will indirectly improve as a result of the reduction of total suspended particle (TSP) or PM, PM10, SO2, NOx and other harmful compounds that contribute to acid rain, increased air and water pollution. The CHP5 Project will have the following other benefits in the area: (i) increase district heating supply of 12.5 million GJ; (ii) increase power generation capacity of 4,100 million kWh annually; (iii) reduce incidence of traffic hazards caused by coal and slag transport vehicles in the urban areas; (iv) reduce secondary ash pollution in ash pond area due to the ash being beneficially utilized for construction material and little or no ash will be deposited in ash pond, and (v) improve public health and the living environment in areas now affected by emissions, noise, and flue dust from the outdated CHP plants and
HOB houses, water heaters, and family heating stoves.

303. Projected reductions in coal usage and pollutants emissions due the CHP5 Project are summarized in Table 8.1 below:

**Table 8.1: Estimated Emission Reductions and Coal Saving (ton/annum)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CHP2</th>
<th>CHP3</th>
<th>HOB</th>
<th>CHP5</th>
<th>Coal Saving/Emission Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Consumption (standard coal)</td>
<td>89,700</td>
<td>174,000</td>
<td>640,000</td>
<td>577,100$^{19}$</td>
<td>327,000</td>
</tr>
<tr>
<td>Coal consumption (raw coal)</td>
<td>183,000</td>
<td>350,000</td>
<td>1,445,000</td>
<td>1,353,300</td>
<td>766,800</td>
</tr>
<tr>
<td>SO$_2$ emission</td>
<td>1,760</td>
<td>3,360</td>
<td>13,870</td>
<td>2,600</td>
<td>16,390</td>
</tr>
<tr>
<td>NO$_x$ emission</td>
<td>2,060</td>
<td>3,930</td>
<td>16,240</td>
<td>3,040</td>
<td>19,190</td>
</tr>
<tr>
<td>Flue dust emission (TSP)</td>
<td>8,200</td>
<td>8,000</td>
<td>450,000</td>
<td>54</td>
<td>466,146</td>
</tr>
<tr>
<td>CO$_2$ emission</td>
<td>250,900</td>
<td>433,800</td>
<td>1,595,500</td>
<td>1,438,700</td>
<td>815,200</td>
</tr>
</tbody>
</table>

*Source: TA Team estimates.*

304. After CHP5 Plant starts operation, the existing CHP2, the low pressure system of the CHP3, and hundreds of small coal-fired HOBs will be replaced. In additional CHP5 will provide millions kWh more power generation to the power grid. Compared with the current emissions including those from CHP2, CHP3, and HOBs, it is expected that only coal consumption and the CO$_2$ emission will increase by about 1.64 million ton/annum and 6.77 million ton/annum, respectively, as shown in Table 8.2. The emission loads of SO$_2$, NO$_x$ and flue dust will be significantly reduced; therefore, the overall environmental impact to UB from the CHP plant is positive.

**Table 8.2: Increase and Decrease in Coal Consumption and Emissions (ton/annum)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Coal Consumption &amp; Emission$^{18}$</th>
<th>Expected CHP5 Coal Consumption &amp; Emission</th>
<th>Increase or Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Coal Consumption</td>
<td>1,978,000</td>
<td>3,620,000</td>
<td>+1,642,000</td>
</tr>
<tr>
<td>SO$_2$ emission</td>
<td>18,990</td>
<td>6,950</td>
<td>-12,040</td>
</tr>
<tr>
<td>NO$_x$ emission</td>
<td>22,230</td>
<td>8,130</td>
<td>-14,100</td>
</tr>
<tr>
<td>Flue dust emission (PM)</td>
<td>557,000</td>
<td>145</td>
<td>-556,850</td>
</tr>
<tr>
<td>CO$_2$ emission</td>
<td>2,253,000</td>
<td>9,025,000</td>
<td>+6,772,000</td>
</tr>
</tbody>
</table>

*Source: TA Team estimates.*

F. Anticipated Environmental Impacts and Proposed Mitigation Measures

305. **Screening of Potential Impacts.** The potential impacts have been screened during the EIA process in order to: (i) identify the relative significance of potential impacts from the

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$^{18}$ The low-pressure system only, the high-pressure system will be retained.

$^{19}$ Not include coal consumption for increased power supply.

$^{20}$ Include coal consumptions of and emissions from the CHP2, the low pressure part of the CHP3 and HOBs to be replaced.
activities of the proposed CHP5; (ii) establish the scope of the assessment which assists in focusing on major, critical, and specific impacts; and (iii) enable flexibility in regard to consideration of new issues, such as those that reflect the requirements by ADB’s SPS and Mongolian national regulation, if any.

306. The impacts are grouped under three general categories: physical, biological, and socio-economic. Impacts during design, construction, and operation phases will be considered separately. Potential impacts from the Project considered under the following categories: (i) direct impacts: those directly due to the Project itself; (ii) induced impacts: those resulting from activities arising from the Project, but not directly attributable to it; and (iii) cumulative impacts: impacts which in combination would exert significant additional influence.

307. Environmental Impacts and Mitigation Measures during Construction. The environmental impacts during construction have been assessed in the EIA report, which mainly include: i) soil erosion, soil contamination, and surplus spoil disposal; ii) water pollution; iii) noise and vibration due to various construction and transport activities; iv) dust from excavation, concrete mixing, transportation of the construction materials and excavation spoil, and dust soil from disturbed and uncovered construction areas and other construction activities, especially in windy days; v) vehicle emission from construction vehicles, especially heavy diesel machineries and equipment; and vi) socioeconomic impacts. Fugitive dust may be caused by excavation, demolition, vehicular movement, and materials handling, particularly downwind from the construction sites. The dust and emission caused by pipeline ditch excavation, backfill, and vehicle movement could affect nearby residential areas, hospitals and schools; vii) solid wastes from construction and demolition of the existing CHP plants, as well as the HOB houses, and the coal-fired water heaters, especially risks caused by asbestos during demolishing work. The comprehensive corresponding mitigation measures have been proposed in the EIA report.

308. Environmental Impact and Mitigation Measures during Operation. The environmental impacts of the CHP5 Project will take place during operation. The potential impacts during operation will be noise from the generators and cooling towers; risk from oil spill and fire; air pollution from flue gas emissions, specifically SO₂, NOx, and PM10; water pollution; and solid waste (mainly ash). The main impact during decommissioning is the disposal of soil that might be contaminated with spilled chemicals and lubricants. The CHP5 plant will not use any polychlorinated biphenyls or asbestos, which were typically used in power plants built before 1980s.

309. Expected Pollutant Emissions. The estimated emission concentrations of SO₂, flue dust, and NOx from the CHP5 plant will be 120 milligrams per cubic meter (mg/m³), 50.0 mg/m², and 130 mg/m², respectively, which meet the Mongolian standards as well as World Bank standards (Table 8.3).

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Item</th>
<th>Unit</th>
<th>Emission</th>
<th>World Bank Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>Emission concentration</td>
<td>mg/Nm³</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Hourly emission rate</td>
<td>ton/hr</td>
<td>0.4</td>
<td>80</td>
</tr>
<tr>
<td>TSP</td>
<td>Emission concentration</td>
<td>mg/Nm³</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Hourly emission rate</td>
<td>ton/hr</td>
<td>0.1</td>
<td>50</td>
</tr>
<tr>
<td>NOx</td>
<td>Emission concentration</td>
<td>mg/Nm³</td>
<td>130</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Hour emission rate</td>
<td>ton/hr</td>
<td>2.0</td>
<td>1000</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

310. Solid waste disposal and ash utilization. The CHP5 will use lignite coal as fuel which will generate about 0.27 million tons of coal ash per annum from 2016-2020 and 0.53
million tons of ash per annum from 2021 (ash contents of the lignite is about 9-10%). The ash could cause some ecological problems if not managed properly.

311. Ash utilization is desirable to avoid the adverse environmental impacts that can result from ash disposal. It is proposed that most of the ash produced by CHP plant will be utilized for road bed filling material, and raw materials for brick and cement production, or similar uses.

312. Radiation of the coal ash. According to the test results (Table 7.6), the fly ash and the bottom ash from the existing CHP3 and CHP4 plants contain acceptable level radioactive isotopes, e.g., $^{40}\text{K}$, $^{232}\text{Th}$, and $^{238}\text{U}$, and their decay products ($^{222}\text{Rn}$, $^{228}\text{Ra}$, $^{220}\text{Rn}$ with their radioactive progenies). Since the radioactive intensities are low (around 200 Bq/kg), they can be utilized as refill material in infrastructure (road and building) construction and as constituents of many types of outdoor building products based on the current Mongolian standard$^{21}$.

313. Summary of the major mitigation measures. The proposed pollution mitigation measures are summarized as follows: i) building 250 m stacks to disperse and minimize the direct impact of emissions on adjacent areas; ii) using ESP with a dust removal efficiency of at least 99.6%; iii) using desulfurization inside the CFB boiler that is about 80% or more efficient; iv) using CFB plus SNCR equipment with a total denitrification rate of about 80%, with which the emission concentration will be lower than 150 mg/m$^3$; v) installing an online automatic monitor on the stacks of the CHP5 plant to monitor $\text{SO}_2$ and PM emissions; vi) utilizing coal ash as material of construction or raw material for cement plants; and vii) installing mufflers on vents of the boiler and air blowers and sound-proof shields on the power generators to mitigate the noise impact.

G. Environmental Mitigation Costs

314. The environmental protection related costs is estimated at $67.67 million, or 4.97% of the total estimated base cost of the Project. The major environmental protection costs for the CHP5 Project are summarized in Table 8.4 below.

<table>
<thead>
<tr>
<th>Pollution Control Facility/equipment</th>
<th>Cost (Million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic precipitator (ESP)</td>
<td>13.07</td>
</tr>
<tr>
<td>Flue gas desulfurization system</td>
<td>4.62</td>
</tr>
<tr>
<td>(inside the bed of CFB)</td>
<td></td>
</tr>
<tr>
<td>Flue gas denitration system (SNCR)</td>
<td>18.64</td>
</tr>
<tr>
<td>Ash handling system</td>
<td>9.18</td>
</tr>
<tr>
<td>Circulating water system</td>
<td>0.56</td>
</tr>
<tr>
<td>Ash storage facilities</td>
<td>13.95</td>
</tr>
<tr>
<td>Environmental monitoring instruments</td>
<td>1.65</td>
</tr>
<tr>
<td>Landscaping</td>
<td>1.0</td>
</tr>
<tr>
<td>Noise control measures</td>
<td>5.0</td>
</tr>
<tr>
<td>Total environmental protection</td>
<td>67.67</td>
</tr>
<tr>
<td>investment</td>
<td></td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

$^{21}$ Mongolian Standard for Radiation levels in Construction Materials (MNS 5072-2001) stipulates that the limits for radiation levels for inside building construction materials, urban road and bridge construction and highway and bridges outside cities are 370 Bq/kg, 740 Bq/kg and 1,200 Bq/kg, respectively.
H. CDM Assessment

315. A Clean Development Mechanism (CDM) assessment was conducted during the EIA study. The major conclusions are summarized in this section of the report.

316. The Project is likely to meet all the key CDM criteria except for CDM additionality, which requires further due diligence and study. There are no technological barriers as such but a detailed review during the preparation of the Project Design Document (PDD) would be necessary. The additional revenue from CDM can help the CHP5 developer(s) to replace the existing CHP plants as well as the HOBs with high efficiency, environmental friendly modern CHP technologies in order to maintain the good operating conditions and to reduce coal consumption and greenhouse gas (GHG) emission.

317. The Project falls under “Energy Conservation,” an eligible project type. There are already approved methodologies for energy efficiency improvement, i.e.: i) AM0058 (Introduction of a new primary district heating system), and ii) AM0048 (New cogeneration facilities supplying electricity and/or steam to multiple customers and displacing). Both the methodologies will be evaluated before deciding a particular one.

318. The most important issue is that a proper institutional arrangement has to be established before the CHP5 implementation in order to carry out CDM-related activities on behalf of UB municipality or MMRE. There also has to be a transparent system for equitable distribution system of carbon revenue to the CHP5 developer and the heating supply enterprises, as well as defining the associated CDM roles and responsibilities.

319. To participate in the CDM, the host country should have signed and ratified the Kyoto Protocol, or at the very least, have given an indication that they intend to ratify the Kyoto Protocol in the near term. In addition, participation in the CDM requires that the host country establish an institutional framework for assessing and approving CDM projects.

320. Mongolia ratified the UNFCCC on 30 September 1993 and ratified the Kyoto Protocol on 15 December 1999. The Designated National Authority (DNA) has been established and is headed by the Ministry of Nature, Environment and Tourism.

321. Additionality. The analysis of the additionality requires further due diligence and detailed analysis and baseline estimation to see if the Project meets the additionality test. There are apparently no institutional or technological barriers as such. However, in addition to the outdated CHPs, there are 89 HOB houses with total thermal capacity of 140 Gcal/hr and the efficiency rate of 50% to 60%. Moreover, 1,005 coal-fired water heaters with total capacity of 18.6 Gcal/hr are in operation. The total coal consumption reached 19,857 tons in 2008. Also, there were about 103,971 heating stoves used to heat the gers or houses.

322. Since the coal price in Mongolia is much cheaper than the international market, the investment of the CHP5 plant is really high (approximately $1.35 billion). Also, because lending practices from local commercial banks are still weak in Mongolia (annual loan interest is more than 20%), users of the existing heating facilities many continue using the existing facilities rather than change to high efficiency CHP system without the revenue from CDM.

323. Mongolia’s current emission standards are based on emission measurements from existing boilers. The measurement amounts are used as emission standards for the specific type of boilers (Table 8.5). There are no certain patterns to follow with boiler type or size (capacity). Since the current standards are not strictly enforced, the heating users would rather continue to use the existing heating facilities than build a new CHP plant without revenue from CDM.
Table 8.5: Emission Standard for Coal-Fired Boilers in Mongolia

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>mg/nm³⁰</td>
<td>600-2,700</td>
</tr>
<tr>
<td>NOₓ</td>
<td>mg/nm³⁰</td>
<td>300-1,900</td>
</tr>
<tr>
<td>PM</td>
<td>mg/nm³⁰</td>
<td>200-20,000+</td>
</tr>
</tbody>
</table>

324. **Contribute to Sustainable Development.** One of the purposes of the CDM is to assist developing countries in achieving sustainable development. Therefore, the Project must contribute to the Host Country’s sustainable development objectives and should satisfy any pre-determined sustainable development criteria.

325. The Country Strategy and Program (2006–2008) identified inclusive social development as one of two strategic pillars; improved urban services, environment and housing for the poor are targeted as key outcomes. If successful, the Project will: i) reduce the coal consumption by employing highly efficient CHP technology; ii) reduce considerably health damaging air pollutants; and iii) demonstrate a highly replicable clean technology CDM project.

326. The DNA for CDM requires an official request letter, a PDD and other Project documents to review and provide the letter of no objection. Getting DNA approval should be straightforward.

327. **Measurable Emission Reductions.** The emission reductions of the Project need to be measurable and need to be validated and verified by an Operational Entity. This is to ensure that any emission reductions claimed have actually occurred. The source of emission reductions for this Project is the reduction of coal consumption based on the baseline scenario. The amount of coal consumed after implementation of the Project can be monitored, which can then be compared with that before replacement of the existing CHP2, CHP3 and HOBs.

328. **Potential Emission Reduction.** The proposed CHP5 will save up to 30% of fuel consumption per kWh electricity generated in comparison with the conventional electric-only plant. Furthermore, a CHP scenario will consume 25~35% less fuel per GJ heat produced in comparison with HOB plants. Totally, the CHP5 will save 766,800 tons of raw coal each year due to its higher efficiency, as compared to the existing CHP plants and coal-fired HOBs. The estimated CO₂ emission reduction is 447,400 tons/yr after 2015 (Phase I), and 815,200 tons/yr after 2020 (Phase II). The United Nations Framework Convention on Climate Change (UNFCCC) default emission factor of 104.74 t CO₂/TJ can be used for the CDM CER calculation.

329. **Estimated Cost for CDM development.** For a project developer, it is important to have an indication of what the additional costs (i.e., transaction costs) are for developing a project as a CDM project. The World Bank Prototype Carbon Fund (PCF) had estimated transaction costs for developing a new CDM project in the order of $250,000-350,000 (including about $50,000 for PDD preparation). This figure includes activities such as consultancy fees, fees for validation of project documentation, and development of an Emission Reduction Purchase Agreement (ERPA).

330. The registration fee levied by the CDM Executive Board would be the share of proceeds applied to the expected average annual emission reduction for the Project activity over its crediting period. More detailed information is provided in Appendix 4.

I. Public Consultation and Environmental Management Plan

331. Two rounds of public consultation were held in December 2010 and March 2011
respectively in UB and results indicated that the majority of the stakeholders had a positive attitude toward the CHP5 Project and believed that the proposed scheme would benefit the local economy, raise the quality of life, improve local environmental conditions, and contribute to global climate change mitigation. People consulted generally believed any adverse environmental impacts associated with the Project will be prevented, reduced, minimized, or otherwise compensated.

332. Furthermore, an environmental management system involving environmental management and supervision organizations, environmental monitoring, and institutional strengthening will be established to ensure the environmental performance of the Project. To ensure successful implementation of these measures, the EMP covers major relevant aspects such as institutional arrangement for environmental management and supervision and environmental monitoring and training. With implementation of the mitigation measures defined in the EIA and EMP, the adverse impacts will be reduced to acceptable levels. Overall, the Project is environmentally sound and will promote balanced and environmentally sustainable urbanization and economic growth in UB and Mongolia.
IX. FINANCIAL ANALYSIS

A. Introduction

333. The financial analysis of the proposed CHP5 project involves the preparation of a preliminary cost estimate, financial analysis\(^{22}\) and financial plan. The analysis is carried out in accordance with ADB’s *Financial Management and Analysis of Projects* (2005).

334. The Mid Term Report presented a preliminary financial analysis of constructing the plant at three alternative sites. The three options were considered are:

- Option 1: CHP5 at Uliastai site in east Ulaanbaatar (UB);
- Option 2: Conventional Power Plant at Baganuur near the coal mine and heat only boilers at UB; and
- Option 3: CHP5 on the existing CHP3 site.

335. The analysis demonstrated that Option 3 was the least cost option and it was also determined from a technical perspective to be the most preferable option. A decision was taken by the MMRE that further analysis should be carried out for this option, which was then presented in the draft version of this final report.

336. Under Option 3 there are two sub-options, one is to remove the low-pressure system and the other is to remove both the low-pressure system and the HP system of the CHP3 plant. The “with HP system retained” sub-option is selected as the core option for this main report as this option costs less and there is also a desire to keep HP by some stakeholders. The “without HP system” sub-option is also described in detail in Appendix 10.

B. Methodology

337. A financial model was developed by the TA Team to prepare projected financial statements of the proposed CHP5 project company\(^{23}\) over a period of 30 years, i.e. its projected Profit and Loss Account, Balance Sheet and Cashflow Statement based on a level of tariff to achieve a satisfactory rate of return. The general assumptions used for the financial analysis are presented in Subsection C below. Based on the financial statements a project cashflow was prepared to calculate financial indicators such as Financial Internal Rate of Return (FIRR) and Net Present Value (NPV) to assess financial viability of CHP5 project.

338. In addition to the above indicators certain other financial ratios which depict the financial health of CHP5 operations such as Debt Service Coverage Ratio (DSCR), Debt to Equity Ratio etc are also calculated through the financial model as well as certain profitability indicators.

339. The manner in which CHP5 is to be financed is yet to be determined by the Government. On the one hand there is a possibility that it may be an entirely public sector project financed by ADB and / or bi-lateral donors while on the other hand it may be financed as a Public Private Partnership (PPP) project (see Section X) or a commercially financed project. The financial analysis uses the first as the Base Case Scenario and uses two other

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\(^{22}\) Including financial internal rate of return, weighted average cost of capital, sensitivity analysis, projected financial statements

\(^{23}\) Assumed to be a single project company just responsible for the construction and O&M of the CHP5 plant associated support facilities.
financing scenarios, namely, PPP and commercial financing as alternative scenarios.

340. Similarly the analysis also presents two tariff scenarios, the first is a cost reflective tariff based on the Energy Regulatory Authority of Mongolia (ERA) tariff setting methodology\(^{24}\) and the other is based on the current CHP4 level of tariff.

341. The analysis also presents a final scenario of constructing Phase I of CHP5 only with a capacity of 450 MW electricity and 453 Gcal/hr of heating and both Phase I and Phase II with a capacity of 820 MW electricity and 1,101 Gcal/hr of heating.

342. During the discussion of the DFR, MMRE indicated that they would be interested in seeing a scenario entirely in current terms to demonstrate the current price level tariffs. Therefore Scenario 19 is added and it depicts current price level cost reflective tariffs and other indicators for PPP financing.

343. Furthermore, MMRE also requested that several scenarios be presented where the HP system of CHP3 is removed. Scenarios 20-32 are related to this aspect.

344. Therefore a total of 32 scenarios are presented in the financial analysis and they are as follows.

- **Scenario 1** based on 100% ADB / Bi-lateral financing, at a cost reflective tariff with both Phase I and Phase II;
- **Scenario 2** based on 100% ADB / Bi-lateral financing, at the CHP4 tariff with both Phase I and Phase II;
- **Scenario 3** based on 100% ADB / Bi-lateral financing, at a cost reflective tariff with only Phase I;
- **Scenario 4** based on 100% ADB / Bi-lateral financing, at the CHP4 tariff with only Phase I;
- **Scenario 5** based on 100% ADB / Bi-lateral financing, with a 15% increase on the CHP4 tariff with both Phase I and Phase II;
- **Scenario 6** based on 100% ADB / Bi-lateral financing, with a 15% increase on the CHP4 tariff with only Phase I;
- **Scenario 7** based on PPP financing, at a cost reflective tariff with both Phase I and Phase II;
- **Scenario 8** based on PPP financing, at the CHP4 tariff with both Phase I and Phase II;
- **Scenario 9** based on PPP financing, at a cost reflective tariff with only Phase I;
- **Scenario 10** based on PPP financing, at the CHP4 tariff with only Phase I;
- **Scenario 11** based on PPP financing, with a 15% increase on the CHP4 tariff with both Phase I and Phase II;
- **Scenario 12** based on PPP financing, with a 15% increase on the CHP4 tariff with only Phase I;
- **Scenario 13** based on 100% commercial financing, at a cost reflective tariff with both Phase I and Phase II;
- **Scenario 14** based on 100% commercial financing, at the CHP4 tariff with both Phase I and Phase II;

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\(^{24}\) This is a cost recovery based methodology with a return on investment based on debt service cost to net fixed assets.
Scenario 15 based on 100% commercial financing, at a cost reflective tariff with only Phase I;

Scenario 16 based on 100% commercial financing, at the CHP4 tariff with only Phase I;

Scenario 17 based on 100% commercial financing, with a 15% increase on the CHP4 tariff with both Phase I and Phase II;

Scenario 18 based on 100% commercial financing, with a 15% increase on the CHP4 tariff with only Phase I;

Scenario 19 based on PPP financing, at a cost reflective tariff with both Phase I and Phase II in current terms;

Scenario 20 based on 100% ADB / bilateral financing, at a cost reflective tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 21 based on 100% ADB / bilateral financing, at the CHP 4 tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 22 based on 100% ADB / bilateral financing, at a cost reflective tariff with only Phase I without HP system of CHP3;

Scenario 23 based on 100% ADB / bilateral financing, at the CHP 4 tariff with only Phase I without HP system of CHP3;

Scenario 24 based on 100% ADB / bilateral financing, with a 15% increase on the CHP 4 tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 25 based on 100% ADB / bilateral financing, with a 15% increase on the CHP 4 tariff with only Phase I without HP system of CHP3;

Scenario 26 based on PPP financing, at a cost reflective tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 27 based on PPP financing, at the CHP 4 tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 28 based on PPP financing, at a cost reflective tariff with only Phase I without HP system of CHP3;

Scenario 29 based on PPP financing, at the CHP 4 tariff with only Phase I without HP system of CHP3;

Scenario 30 based on PPP financing, with a 15% increase on the CHP 4 tariff with both Phase I and Phase II without HP system of CHP3;

Scenario 31 based on PPP financing, with a 15% increase on the CHP 4 tariff with only Phase I without HP system of CHP3;

Scenario 32 based on PPP financing, at a cost reflective tariff with both Phase I and Phase II in current terms without HP system of CHP3.

The PPP Scenario (with the HP system of CHP3 retained), for both Phase I and II with cost reflective tariffs is presented as the core scenario in this section and Appendix 5 with a full set of financial statements, whilst the other scenarios are presented in a summary table with key results in Subsection G.

C. General Assumptions

General assumptions for the financial analysis are common for all scenarios. These are as follows:
i) All cashflows are incremental;

ii) All prices are at Constant mid-2010 price level;

iii) Projections are made over a 30 year period from 2013 to 2042 with no residual value at the end of 2042;

iv) The installed capacity for power is 820 MW and heating 1,281 MWt (1,101 Gcal/hr) on the assumption that CHP2 and low pressure system of CHP3 will be de-commissioned$^{25}$ once CHP5 is commissioned. The CHP5 plant will be constructed on a modular basis with Phase I of approximately 450 MW coming on stream in 2015 and Phase II for the balance in 2020;

v) The electricity and heat demand is estimated based on estimates from MMRE and the UB Governor’s office respectively. On the basis of the existing demand projections, 820 MW of electricity demand and 1,281 MWt (1,101 Gcal/hr) of heating demand will be covered by the CHP5 by the year 2020;

vi) The currency used is the Mongolian Tugruk (MNT) and exchange rate used is $1=1,300 MNT;

vii) The source of coal is from two mines, Baganuur and Shivee-Ovoo supplying 30% and 70% of the requirement respectively and price of 18,200 MNT/ton and 13,960 MNT/ton respectively. MMRE has forecast that the price of coal will rise sharply in the short to medium term to MNT 24,889 /ton from Baganuur and MNT 18,589/ton from Shivee Ovoo by 2013. The transport cost is assumed at 3,288 MNT/ton and 4,080 MNT/ton respectively. The heating value of coal from Baganuur is 3,400 kCal/kg and Shivee Ovoo is 2,900 kCal/kg;

viii) The working capital requirement is assumed at 45 days of total operational expenses excluding coal. Working capital is the monetary source to finance operations for the period between paying payables and collecting receivables;

ix) The average salary and related allowances per person is MNT 9.5 million per annum based on current salary costs of the CHP4 plant. Employer social security and health contributions are assumed at 13% of salary and allowances. It is assumed that 648 staff will be required for CHP5;

x) Capital costs as estimated by the TA team are presented in Subsection D;

xi) Taxes on income have been assumed at 10% of accounting profit up to a maximum of MNT 3 billion and thereafter at 25% of profits exceeding MNT 3 billion;

xii) O&M costs, excluding coal and salaries are assumed to be 3% of the capital cost.

D. Cost Estimate

347. Phase I and Phase II Cost Estimates. Table 9.1 presents the cost estimates of CHP5 for Phase I and Phase II, i.e., with a power capacity of 820 MW and heating capacity of 1,281 MWt (1,101 Gcal/hr). This is under the assumption that low-pressure system would be remove while the HP system would be retained.

---

$^{25}$ Except for the high-pressure system of CHP3 which will be rehabilitated and maintained.
Table 9.1: CHP5 Cost Estimates for Phase I and Phase II

<table>
<thead>
<tr>
<th>Source: TA Team estimates.</th>
</tr>
</thead>
</table>

348. Base costs do not include contingencies but include custom tax at 5% and value added tax at 10%. Physical contingencies are based on 10% of base costs. Price contingencies are based on inflation estimates\(^{26}\) for foreign and local costs. It is estimated that 75% of civil works costs, 100% of equipment costs and 90% of equipment installation costs are foreign. Duties and taxes are local costs. It is also assumed that Phase I will commence in 2013 and have disbursements of 15%, 20% and 15% until 2015. Phase II will commence in 2018 and have a similar pattern of disbursements until completion in 2020.

349. Interest during construction (IDC) represents the interest cost on financing during the period of construction which is capitalized and amortized rather than expensed in accordance with generally accepted practice. After project completion, interest is charged to the Profit and Loss Account.

350. **Phase I only Cost Estimates.** Table 9.2 presents the cost estimate for Phase I only, i.e., with a power capacity of 450 MW and heating capacity of 527 MWe (453 Gcal/hr).

---

26 Local inflation at 6% and foreign inflation at 2%
Table 9.2: CHP5 Cost Estimates for Phase I

<table>
<thead>
<tr>
<th>MNT Millions</th>
<th>US$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foreign</td>
</tr>
<tr>
<td>1. Land and Compensation</td>
<td>-</td>
</tr>
<tr>
<td>2. Civil Works</td>
<td>98,019.9</td>
</tr>
<tr>
<td>3. Dismantling Costs of CHP3</td>
<td>16,478.2</td>
</tr>
<tr>
<td>4. Equipment</td>
<td>-</td>
</tr>
<tr>
<td>Boilers</td>
<td>97,458.6</td>
</tr>
<tr>
<td>Turbines and Generators</td>
<td>89,352.0</td>
</tr>
<tr>
<td>Other Thermodynamic System related Equipment</td>
<td>1,909.7</td>
</tr>
<tr>
<td>Fuel Conveying System</td>
<td>8,317.3</td>
</tr>
<tr>
<td>Ash Transferring System</td>
<td>4,294.3</td>
</tr>
<tr>
<td>Water Supply System</td>
<td>987.1</td>
</tr>
<tr>
<td>Water Treatment System</td>
<td>9,142.3</td>
</tr>
<tr>
<td>Electrical System</td>
<td>25,882.8</td>
</tr>
<tr>
<td>C&amp;I System</td>
<td>16,147.2</td>
</tr>
<tr>
<td>Transmission Lines and Heating Pipelines</td>
<td>33,882.2</td>
</tr>
<tr>
<td>Auxiliary Engineering</td>
<td>2,814.9</td>
</tr>
<tr>
<td>Other</td>
<td>58,444.5</td>
</tr>
<tr>
<td>Total</td>
<td>584,444.9</td>
</tr>
</tbody>
</table>

CONTINGENCIES

<table>
<thead>
<tr>
<th>MNT Millions</th>
<th>US$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foreign</td>
</tr>
<tr>
<td>1. Physical Contingencies</td>
<td>58,444.5</td>
</tr>
<tr>
<td>2. Price Contingencies</td>
<td>30,284.0</td>
</tr>
<tr>
<td>Total Contingencies</td>
<td>88,728.4</td>
</tr>
</tbody>
</table>

INTEREST DURING CONSTRUCTION

<table>
<thead>
<tr>
<th>MNT Millions</th>
<th>US$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foreign</td>
</tr>
<tr>
<td>21,455.2</td>
<td>16.5</td>
</tr>
</tbody>
</table>

TOTAL PROJECT COST

<table>
<thead>
<tr>
<th>MNT Millions</th>
<th>US$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foreign</td>
</tr>
<tr>
<td>694,628.5</td>
<td>171,520.8</td>
</tr>
</tbody>
</table>

Note: Total Taxes and Duties USD 70 million

Source: TA Team estimates.

E. Financing Plan

351. The financing plan sets out the manner in which the project costs are to be financed. Three methods of financing have been considered for the financial analysis:

i) 100% ADB and/or bi-lateral concessional financing on the basis of an interest rate of 4.18%\(^27\) (representing a 20 year fixed swap rate in US Dollars) and repayment over a 20 year period with a grace period on repayment of 5 years. Furthermore during the construction period the interest rate is assumed to be 2.54%, representing a five year fixed swap US Dollar rate of 2.37% plus a margin of 40 basis points less rebate of 23 basis points);

ii) 100% commercial borrowing at a cost of 11%\(^28\) per annum also over a 20 year period with a grace on repayment of 3 years. It is assumed that the same interest rate will be applicable during construction;

iii) A PPP approach involving 70% of the project cost as concessionary financing and from ADB on the above terms and the 30% balance of project costs as private equity.

F. Current Tariff Structure and Tariffs Used for CHP5

352. The electricity and heating tariff is determined by the ERA based on the revenue requirement to cover costs and earn a return on investment. Therefore higher costs have a direct impact on the tariff with a resultant higher tariff.

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\(^{27}\) www.adb.org/documents/brochures/libor/indicative_rates.pdf as of 2 March 2011

\(^{28}\) Evaluating Possible Public Private Partnership Modalities for CHP5, Castalia Strategic Advisors, October 2010
353. The current off-taker tariffs and final retail tariffs are presented in Table 9.3. CHP4, being the largest generator has the lowest tariff due to economies of scale. Over the 10-year period 2000-2010, the electricity and heating retail tariffs have increased by an annual average of 8.5% and 6.6%, respectively.

### Table 9.3: Current Off-taker and Retail Tariffs

<table>
<thead>
<tr>
<th>Item</th>
<th>CHP 2</th>
<th>CHP 3</th>
<th>CHP 4</th>
<th>Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Tariff</td>
<td>MNT 64.05/kWh</td>
<td>MNT 60.90 / kWh</td>
<td>MNT 35.85 / kWh</td>
<td>MNT 79.80/kWh</td>
</tr>
<tr>
<td>Heating Tariff</td>
<td>MNT 7,623 / GCal</td>
<td>MNT 7,718 / GCal</td>
<td>MNT 7,533 / GCal</td>
<td>MNT 10,600 / GCal</td>
</tr>
<tr>
<td>Average Annual Tariff Increase 2000-2010</td>
<td>Power: 8.5%</td>
<td>Heat: 6.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity Distributed 2009</td>
<td>100,237 thou.kWh</td>
<td>520,260 thou.kWh</td>
<td>2,329,381 thou kWh</td>
<td></td>
</tr>
<tr>
<td>Heat Distributed, 2009</td>
<td>147.4 thou.Gcal</td>
<td>1,072.9 thou. Gcal</td>
<td>3,052.6 thou.Gcal</td>
<td></td>
</tr>
<tr>
<td>Total Prime Cost29, 2009</td>
<td>MNT 7,086 million</td>
<td>MNT 47,041 million</td>
<td>MNT 98,510 million</td>
<td></td>
</tr>
<tr>
<td>Total Revenue, 2009</td>
<td>MNT 6,821 million</td>
<td>MNT 39,888 million</td>
<td>MNT 95,653 million</td>
<td></td>
</tr>
<tr>
<td>Cost Recovery %</td>
<td>96%</td>
<td>85%</td>
<td>97%</td>
<td></td>
</tr>
<tr>
<td>Electricity Prime Cost, 2009</td>
<td>MNT 48.8/kWh</td>
<td>MNT 50.8/kWh</td>
<td>MNT 28.7 / kWh</td>
<td></td>
</tr>
<tr>
<td>Electricity Revenue, 2009</td>
<td>MNT 59.3 /kWh</td>
<td>MNT 56.8/kWh</td>
<td>MNT 33.6 / kWh</td>
<td></td>
</tr>
<tr>
<td>Cost Recovery %</td>
<td>122%</td>
<td>118%</td>
<td>117%</td>
<td></td>
</tr>
<tr>
<td>Heating Prime Cost, 2009</td>
<td>MNT 14,962 /Gcal</td>
<td>MNT 12,116/Gcal</td>
<td>MNT 10,408/Gcal</td>
<td></td>
</tr>
<tr>
<td>Heating Revenue, 2009</td>
<td>MNT 5,965/Gcal</td>
<td>MNT 6,067/Gcal</td>
<td>MNT 5,731/Gcal</td>
<td></td>
</tr>
<tr>
<td>Cost Recovery</td>
<td>40%</td>
<td>50%</td>
<td>55%</td>
<td></td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

354. The present level of tariff enables the generators to cover prime cost to a large extent (overall cost recovery of 96%, 85% and 97% respectively for CHP2, CHP3 and CHP4) although there is a significant cross subsidy from electricity to heating. It is however not possible to clearly state that the heating tariff under-recovered costs due to the methodology used for allocation of costs between electricity and heating. Of the production costs, 70% (excluding the cost of coal) is allocated to electricity and 30% to heating. This has been the practice in Mongolia for many years to allocate fixed costs of production to electricity and heating. Had there been less costs allocated to heating the level of cross subsidy would clearly have been less. The ROI is determined based on the debt service cost to the asset base, i.e. net fixed assets and working capital.

355. **Tariff increase.** As of April 2011, the electricity retail tariff of MNT 79.80/kWh has been increased to MNT 100/kWh for some industrial users. Further tariff increases are planned up to 2014 in order to bring the tariffs towards cost recovery levels.

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29 Prime cost refers to total cost excluding debt service.
356. The indicative tariffs for CHP5 can be determined using the ERA methodology. In calculating the ROI the following assumptions have been made.

i) The rate of depreciation is based on the Mongolian Government Decree No. 233 of 2005. In accordance with this Decree, civil structures are depreciated over 60 years, electricity transmission lines and heating pipelines over 35 years, boilers and turbines over 15 years, railway lines over 100 years, water pipelines and pumps over 21 years, asphalt concrete roads over 13 years and railway cars over 25 years; and

ii) Assumptions regarding the financing of CHP5 as described above.

357. **CHP 5 Tariffs.** The electricity and heating tariffs using the ERA methodology for the Private Sector Scenario (2010 constant prices, cost reflective tariff, Phase I and II and 70% ADB/bilateral donor financing and 30% equity financing) are presented in Figure 9.1 and Figure 9.2 below.

**Figure 9.1: CHP5 Electricity Tariff for the Private Sector Scenario**

![Figure 9.1: CHP5 Electricity Tariff for the Private Sector Scenario](source: TA Team)

**Figure 9.2: CHP5 Heating Tariff for the Private Sector Scenario**

![Figure 9.2: CHP5 Heating Tariff for the Private Sector Scenario](source: TA Team)
358. As seen in Figure 9.1, the CHP5 cost reflective tariff is MNT 49/kWh in 2016 (with the completion of Phase I) and rises to MNT 61/kWh on completion of Phase II. and to a maximum of MNT 77/kWh by 2023 due to increased depreciation and Return on Investment (ROI) being recouped through the tariff. With reduced depreciation and ROI, tariffs starts to reduce annually thereafter.

359. The CHP5 cost reflective heating tariff is MNT 21,568/Gcal in 2016 (with the completion of Phase I) and rises to MNT 23,974/Gcal by the completion of Phase II and starts to reduce after 2031. Under the ERA methodology ROI is not allocated to heating and therefore the increase after completion of Phase II is less than for electricity.

360. The current weighted average off-taker tariffs (CHP2, CHP3 and CHP4) are MNT 41.23/kWh and MNT 7,583/Gcal for electricity and heating, respectively. The CHP5 cost reflective tariffs above represent a significant increase from present levels.

G. Projected Financial Statements for CHP5

361. The financial model generates a complete set of projected financial statements for CHP5 for the scenario of PPP, cost reflective tariff and Phase I and II. The complete statements have been presented in Appendix 5. In the table below an extract of the financial statements is presented and described.

Table 9.4: Extract from Projected Financial Statements of CHP5

<table>
<thead>
<tr>
<th>Description</th>
<th>2015</th>
<th>2016</th>
<th>2018</th>
<th>2020</th>
<th>2021</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sales Revenue</strong></td>
<td>131,563</td>
<td>178,212</td>
<td>265,576</td>
<td>355,950</td>
<td>389,771</td>
<td>460,282</td>
<td>528,162</td>
<td>569,909</td>
<td>659,674</td>
</tr>
<tr>
<td><strong>Operating Expenses</strong></td>
<td>29,316</td>
<td>30,323</td>
<td>40,161</td>
<td>60,494</td>
<td>61,119</td>
<td>64,015</td>
<td>68,727</td>
<td>75,032</td>
<td>83,469</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>39,162</td>
<td>39,162</td>
<td>50,910</td>
<td>78,324</td>
<td>78,324</td>
<td>78,324</td>
<td>78,324</td>
<td>78,324</td>
<td>9,807</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td>52</td>
<td>64</td>
<td>7,086</td>
<td>7,172</td>
<td>7,194</td>
<td>14,083</td>
<td>14,727</td>
<td>14,920</td>
<td>7,873</td>
</tr>
<tr>
<td><strong>Profit / (loss) for Year</strong></td>
<td>470</td>
<td>580</td>
<td>23,059</td>
<td>23,316</td>
<td>23,373</td>
<td>45,550</td>
<td>45,982</td>
<td>46,559</td>
<td>25,420</td>
</tr>
<tr>
<td><strong>Net Fixed Assets</strong></td>
<td>795,591</td>
<td>756,429</td>
<td>916,782</td>
<td>1,356,210</td>
<td>1,277,886</td>
<td>984,591</td>
<td>572,972</td>
<td>394,247</td>
<td>314,626</td>
</tr>
<tr>
<td><strong>Loans</strong></td>
<td>584,327</td>
<td>584,327</td>
<td>730,409</td>
<td>1,081,005</td>
<td>1,051,788</td>
<td>847,274</td>
<td>555,111</td>
<td>282,947</td>
<td>58,433</td>
</tr>
<tr>
<td><strong>Reserves</strong></td>
<td>470</td>
<td>1,050</td>
<td>94,679</td>
<td>254,551</td>
<td>483,547</td>
<td>715,120</td>
<td>884,408</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Net Cashflow from Operations</strong></td>
<td>28,304</td>
<td>61,442</td>
<td>94,321</td>
<td>1,081,005</td>
<td>1,051,788</td>
<td>847,274</td>
<td>555,111</td>
<td>282,947</td>
<td>58,433</td>
</tr>
<tr>
<td><strong>Year end Cash Balance</strong></td>
<td>28,304</td>
<td>65,321</td>
<td>144,177</td>
<td>269,118</td>
<td>340,299</td>
<td>602,925</td>
<td>921,573</td>
<td>1,026,589</td>
<td>1,053,427</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

362. Since the cost reflective tariff is used for the above Scenario (including ROI according to ERA formula) profits are shown throughout the projected period. The above table also highlights the initial increase in depreciation and interest cost due to addition of assets and their subsequent decrease due to amortization.

363. The Balance Sheet data depicts the manner in which the fixed asset base is created and amortized and the manner in which it is financed through loans. The availability of profits has resulted in annual increases in the level of reserves.

364. The cashflow statement shows a positive cash generation in each year and a healthy cash balance at the end of each year.

365. Projected Financial Indicators. Table 9.5 presents some financial ratios, the most important in terms of sustainability is the Debt Service Coverage Ratio (DSCR) which indicates ability to service debt, both interest and capital, from operational cash generation. The DSCR exceeding 1.0 indicates such ability and a DSCR of about 1.5 is generally considered to be satisfactory. In these projections, despite being fully funded by debt, the DSCR is at a satisfactory level throughout. The Profit Margin and Return on Capital
Employed are satisfactory for most of the project period although decline during the later years due to the lower tariff required to recover costs.

Table 9.5: Financial Ratios from Projected Financial Statements of CHP5

(MNT million, current prices)

<table>
<thead>
<tr>
<th>Description</th>
<th>2015</th>
<th>2016</th>
<th>2018</th>
<th>2020</th>
<th>2021</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit Margin</td>
<td>0.4%</td>
<td>0.3%</td>
<td>11.7%</td>
<td>7%</td>
<td>6%</td>
<td>10%</td>
<td>9%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Return on Capital Employed</td>
<td>0%</td>
<td>3%</td>
<td>5%</td>
<td>3%</td>
<td>5%</td>
<td>6%</td>
<td>6%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Return on Equity</td>
<td>1%</td>
<td>0%</td>
<td>7%</td>
<td>5%</td>
<td>5%</td>
<td>9%</td>
<td>9%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Debt Service Coverage Ratio (DSCR)</td>
<td>2.6</td>
<td>2.0</td>
<td>2.6</td>
<td>2.1</td>
<td>1.8</td>
<td>2.0</td>
<td>1.4</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

H. Project Financial Viability

366. The financial viability of CHP5 is assessed using the Financial Internal Rate of Return (FIRR) and the Net Present Value (NPV). The FIRR should exceed the Weighted Average Cost of Capital (WACC) for the project to be financially viable. The NPV further re-iterates the FIRR by discounting the cashflows at the WACC. A positive NPV indicates that the project will generate value.

367. **Weighted Average Cost of Capital.** The WACC is determined[^30] on the basis of share of financing by each type of financier and the cost of those funds. Since the FIRR is based on constant prices the WACC also has to be converted to constant prices to facilitate comparison.

Table 9.6: Weighted Average Cost of Capital (WACC) Calculation : Public Sector Scenario

<table>
<thead>
<tr>
<th>ADB / Bi-lateral Loan</th>
<th>Commercial Loan</th>
<th>Equity</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Nominal Cost</td>
<td>4.18%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Taxation Rate</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Tax Adjusted Nominal Cost</td>
<td>3.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Inflation Rate</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Real Cost</td>
<td>1.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>WACC</td>
<td>1.1%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Source: TA Team estimates.

368. The FIRR of CHP5 under public sector financing is 4.4% (both Phase I and II and cost reflective tariff) which exceeds the WACC of 1.1% indicating that it is financially sustainable – which in fact should be the case at the cost recovery tariff. The NPV at the WACC is $412 million.

369. The FIRR of CHP 5 under the PPP scenario is 2.9% (Phase I and II, cost reflective tariff) which is lower than the WACC of 4.2% indicating that further tariff increases are necessary for financial sustainability. The NPV at the WACC is a negative $102 million. The reason for the much higher WACC in the PPP scenario compared with the public sector scenario is the higher cost of equity which is also not allowable for tax unlike the interest.

I. Analysis of Scenarios for financing, tariffs and Phase I and Phase II of CHP5

370. A summary of the analysis is presented in Table 9.8. Scenarios 1-19 relate to the CHP5 with the HP system of CHP3 retained. Scenarios 20-32 relate to CHP5 without the HP system of CHP3.

Table 9.8: Summary of Analysis of Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>FIRR</th>
<th>WACC</th>
<th>FNPV Equity (%)</th>
<th>Period (yrs)*</th>
<th>MNT/kWh</th>
<th>MNT/Gcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1: 100% ADB Borrowing, Phase 1 and II, Cost Recovery Tariff</td>
<td>4.4%</td>
<td>1.1%</td>
<td>412</td>
<td>N/A</td>
<td>N/A</td>
<td>69</td>
</tr>
<tr>
<td>Scenario 2: 100% ADB Borrowing, Phase 1 and II, CHP 4 Tariff</td>
<td>N/A</td>
<td>1.1%</td>
<td>(1,369)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 3: 100% ADB Borrowing, Phase 1 only, Cost Recovery Tariff</td>
<td>4.2%</td>
<td>1.1%</td>
<td>121</td>
<td>N/A</td>
<td>N/A</td>
<td>39</td>
</tr>
<tr>
<td>Scenario 4: 100% ADB Borrowing, Phase 1 only, CHP 4 Tariff</td>
<td>-0.3%</td>
<td>1.1%</td>
<td>(69)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 5: 100% ADB Borrowing, Phase 1 and II, 15% increase on CHP 4 Tariff</td>
<td>N/A</td>
<td>1.1%</td>
<td>(1,069)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 6: 100% ADB Borrowing, Phase 1 only, 15% increase on CHP 4 Tariff</td>
<td>4.3%</td>
<td>1.1%</td>
<td>188</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 7: PPP, Phase 1 and II, Cost Recovery Tariff</td>
<td>2.9%</td>
<td>4.2%</td>
<td>(102)</td>
<td>8%</td>
<td>16</td>
<td>61</td>
</tr>
<tr>
<td>Scenario 8: PPP, Phase 1 and II, CHP 4 Tariff</td>
<td>N/A</td>
<td>4.2%</td>
<td>(1,062)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 9: PPP, Phase 1 only, Cost Recovery Tariff</td>
<td>2.8%</td>
<td>4.2%</td>
<td>(37)</td>
<td>8%</td>
<td>15</td>
<td>36</td>
</tr>
<tr>
<td>Scenario 10: PPP, Phase 1 only, CHP 4 Tariff</td>
<td>0.3%</td>
<td>4.2%</td>
<td>(131)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 11: PPP, Phase 1 and II, 15% increase on CHP 4 tariff</td>
<td>N/A</td>
<td>4.2%</td>
<td>(871)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 12: PPP, Phase 1 only, 15% increase on CHP 4 Tariff</td>
<td>4.9%</td>
<td>4.2%</td>
<td>30</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 13: 100% Commercial Borrowing, Phase 1 and II, Cost Recovery Tariff</td>
<td>4.9%</td>
<td>6.1%</td>
<td>(79)</td>
<td>N/A</td>
<td>N/A</td>
<td>100</td>
</tr>
<tr>
<td>Scenario 14: 100% Commercial Borrowing, Phase 1 and II, CHP 4 Tariff</td>
<td>N/A</td>
<td>6.1%</td>
<td>(1,282)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 15: 100% Commercial Borrowing, Phase 1 only, Cost Recovery Tariff</td>
<td>4.8%</td>
<td>6.1%</td>
<td>(31)</td>
<td>N/A</td>
<td>N/A</td>
<td>44</td>
</tr>
<tr>
<td>Scenario 16: 100% Commercial Borrowing, Phase 1 only, CHP 4 Tariff</td>
<td>-2.7%</td>
<td>6.1%</td>
<td>(269)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 17: 100% Commercial Borrowing, Phase 1 and II, 15% increase on CHP 4 tariff</td>
<td>N/A</td>
<td>6.1%</td>
<td>(1,135)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 18: 100% Commercial Borrowing, Phase 1 only, 15% increase on CHP 4 Tariff</td>
<td>2.0%</td>
<td>6.1%</td>
<td>(145)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 19: PPP, Phase 1 and II, Cost Recovery Tariff in Current terms</td>
<td>2.8%</td>
<td>7.6%</td>
<td>(131)</td>
<td>N/A</td>
<td>N/A</td>
<td>80</td>
</tr>
<tr>
<td>Scenario 20: 100% ADB Borrowing, Phase 1 and II, Cost Recovery Tariff</td>
<td>4.5%</td>
<td>1.1%</td>
<td>551</td>
<td>N/A</td>
<td>N/A</td>
<td>74</td>
</tr>
<tr>
<td>Scenario 21: 100% ADB Borrowing, Phase 1 and II, CHP 4 Tariff</td>
<td>N/A</td>
<td>1.1%</td>
<td>(1,762)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 22: 100% ADB Borrowing, Phase 1 only, Cost Recovery Tariff</td>
<td>4.3%</td>
<td>1.1%</td>
<td>126</td>
<td>N/A</td>
<td>N/A</td>
<td>51</td>
</tr>
<tr>
<td>Scenario 23: 100% ADB Borrowing, Phase 1 only, CHP 4 Tariff</td>
<td>-7.7%</td>
<td>1.1%</td>
<td>(201)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 24: 100% ADB Borrowing, Phase 1 and II, 15% increase on CHP 4 Tariff</td>
<td>N/A</td>
<td>1.1%</td>
<td>(1,423)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 25: 100% ADB Borrowing, Phase 1 only, 15% increase on CHP 4 Tariff</td>
<td>-1.8%</td>
<td>1.1%</td>
<td>(121)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 26: PPP, Phase 1 and II, Cost Recovery Tariff</td>
<td>3.1%</td>
<td>4.2%</td>
<td>(116)</td>
<td>7%</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td>Scenario 27: PPP, Phase 1 and II, CHP 4 Tariff</td>
<td>N/A</td>
<td>4.2%</td>
<td>(1,367)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 28: PPP, Phase 1 only, Cost Recovery Tariff</td>
<td>3.0%</td>
<td>4.2%</td>
<td>(33)</td>
<td>8%</td>
<td>15</td>
<td>46</td>
</tr>
<tr>
<td>Scenario 29: PPP, Phase 1 only, CHP 4 Tariff</td>
<td>-7.5%</td>
<td>4.2%</td>
<td>(264)</td>
<td>N/A</td>
<td>N/A</td>
<td>35.85</td>
</tr>
<tr>
<td>Scenario 30: PPP, Phase 1 and II, 15% increase on CHP 4 tariff</td>
<td>N/A</td>
<td>4.2%</td>
<td>(1,154)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 31: PPP, Phase 1 only, 15% increase on CHP 4 Tariff</td>
<td>-1.1%</td>
<td>4.2%</td>
<td>(154)</td>
<td>N/A</td>
<td>N/A</td>
<td>41</td>
</tr>
<tr>
<td>Scenario 32: PPP, Phase 1 and II, Cost Recovery Tariff in Current terms</td>
<td>3.0%</td>
<td>7.6%</td>
<td>(149)</td>
<td>N/A</td>
<td>N/A</td>
<td>84</td>
</tr>
</tbody>
</table>

*Note: Return on Equity and Payback Period are in Current terms

Source: TA Team estimates.

371. The WACC is the lowest at 1.1% (constant 2010 terms) where all financing is from ADB and/or bi-lateral donors since this is the cheapest source of finance. Under a PPP approach (financing assumptions above), the WACC rises to 4.2% since there is a mixture of more expensive equity.

372. Even at the lowest WACC, the use of the existing CHP4 tariff of MNT 35.85/kWh and...
MNT 7,533/Gcal for electricity and heat respectively results in a negative FIRR and NPV under all scenarios which indicate that the CHP4 tariff is inadequate for CHP5. Even a 15% increase of CHP4 tariffs to MNT 41/kWh and MNT 8,663/Gcal still results in a negative NPV / FIRR.

373. The cost recovery tariffs on completion of the Project are reduced by a factor of almost 30-40% in the event that only Phase I is undertaken. Although this tariff may be more palatable, restriction to Phase I only would result in unmet demand for both electricity and heating in the future.

374. The analysis reveals that even with a cost recovery tariff (under ERA methodology) the FNPV is negative under PPP and Commercial Financing scenarios and the resultant FIRR is less than the WACC. This implies that an additional ROI is needed to increase the FIRR and FNPV which would result in even higher tariffs than presented in Table 9.8.

375. Under PPP (both Phase I and II) financing the tariff would have to be increased by approximately 7% per annum from the levels in Table 9.8 and if Phase I only was undertaken by a factor of 5% per annum on average for the FIRR to exceed the NPV.

376. The MMRE has requested the TA Team to carry out a scenario with a cost reflective tariff for Phase I and II in current terms, which is presented in Table 9.8 as Scenario 19. The WACC has also to be in current terms to facilitate comparison with FIRR. The FIRR is well below the WACC of 7.6% and the tariffs would have to be increased by a further 13% for the FIRR to exceed the WACC.

377. The Return on Equity is defined as the ratio of the average profit after tax available to the equity holder to the average equity investment. It is only calculated where there is a positive return. By definition it is only applicable to the PPP scenarios. The payback period is defined (in years) as the cumulative equity profits to recover the equity investment. Again by this definition it is only applicable to PPP scenarios.

378. Scenarios 20-32 (without HP system of CHP3). The MMRE requested the Consultant to demonstrate the effect of removing the HP system of CHP3. The assumptions used for these scenarios are (i) capital costs increase to US$1.7 billion for Phase I and II compared with US$ 1.3 billion with the HP system; (ii) capital costs for Phase I remain unchanged; (iii) number of employees increase to 700; (iv) electricity installed capacity for Phase I and II is 1,040 MW and heating demand 1,269 Gcal/hr and for Phase I it remains unchanged. All other assumptions are similar to those listed under Subsection C.

379. As in the case of the scenarios with the HP system, the FIRR exceeds WACC for the public sector scenarios with cost reflective tariffs but in the case of PPP scenarios further tariff increases are needed for FIRR to exceed WACC. In other words, from financial analysis point of view, higher tariffs would be required if the HP system of CHP3 is removed assuming CHP5 would cover the power and heat generation from the system. This is because more investment would be necessary under this scenario.

J. Conclusions

380. The financial analysis has presented the financial viability of CHP5 together with its impact on the off-taker tariff. Given that CHP5 is designed using modern technology and is more environmentally friendly, it is understandable that the tariffs would have to increase to make it financially viable given that present tariffs do not recover debt service costs. However the debt service costs depend on the cost and source of financing which is not known at the time of writing.

381. The lowest cost of capital would be with financing from ADB and/or bilateral loans. The cost of capital is higher under a PPP scenario since the private sector would demand a higher return. This would translate into higher tariffs.
382. The analysis also demonstrates the impact of restricting CHP5 to Phase I only. Whilst the reduced capital cost will require less debt financing and therefore a lower tariff, there would be unmet demand in the future.

383. Comparative analyses indicate that higher tariffs would be required to recover costs if the HP system of CHP3 is removed.
X. EVALUATION OF PUBLIC-PRIVATE PARTNERSHIP

A. Introduction

384. This section of the report considers the possible use of a PPP approach to implement the CHP5 project and identifies issues that need to be considered and resolved if such an approach is to be adopted as the principal financing channel for the Project.

385. PPP is identified as a possible alternative financing approach for the CHP5 project in the technical assistance TOR, and is an approach that ADB has agreed to assist the Government fully investigate and evaluate. The detailed consideration of PPP in this final report is contained in Appendix 6 which includes discussion on the following:

i) PPP Related Tasks in the TA Terms of Reference
ii) Background to the Possible Use of PPP for CHP5.
iii) Introduction to PPP and Possible PPP Options for Infrastructure Projects
iv) Evaluation of Options
v) Current Status of CHP5 as a PPP Project
vi) Discussion on Specific Issues:
   ➢ Suggested PPP Model
   ➢ Project Risk and Proposals for Risk Sharing
   ➢ PPP procurement
   ➢ Institutional Capacity of Power & Heat Distributors
   ➢ Off Taker Arrangement
   ➢ Outline Contracts and Agreements
   ➢ Financial Incentives for the PPP Contractor
   ➢ PPP Implementation plan
   ➢ Project Management and technical assistance
vii) Conclusions and Issues to be Addressed

386. The PPP analysis in this report has drawn on and integrated earlier work commissioned by ADB and carried out by Mr. Denzel Hankinson of Castalia Strategic Advisors, also under ADB funding\(^{31}\). This integration was carried out to avoid duplication of effort and possible confusion on the part of stakeholders.

387. The PPP work in the TA has been closely coordinated with some of the technical work, especially the assessment of future energy demand, with the financial analysis (to ensure financial viability) and also with aspects of economic analysis, such as assessment of government borrowing capacity and the socio-economic impact of potential increases in retail power and heating tariffs.

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\(^{31}\) Evaluating Possible Public Private Partnership Modalities for CHP 5, Castalia Strategic Advisors October 2010 (referred to subsequently simply as "the Castalia Report")
B. Background to the Possible Use of PPP for CHP5

1. National Energy Strategy

388. The National Energy Strategy prepared in 2002 by the Government with the assistance of foreign donors\(^{32}\) identified the following goals, strategic principles and key actions for the development and modernization of the Mongolian energy sector.

Goals:
- A financially sustainable sector
- Cost-effective energy access

Strategic Principles:
- Financial sustainability
- Restructuring to foster commercialisation and PSP
- Capacity Building
- Energy Access and Affordability
- Energy conservation

Some key actions identified:
- Privatisation of State owned energy companies to be phased in
- Improve the metering equipment of the Distribution companies
- Create legal frameworks to promote energy conservation and efficiency
- An energy sector privatisation strategy to be prepared

389. The key actions identified in the strategy therefore clearly indicate the Government recognizes that private sector resources need to be mobilized in order to implement the energy strategy and achieve the desired goals.

2. Initial Attempt to Implement CHP5 through Private Sector Investment

390. The concept of the CHP5 project as a means to reinforce the reliability of current power and heating services to UB and meet anticipated demand through to 2025 and beyond has been promoted by MMRE (the responsible Ministry for the Energy sector) for a number of years. In 2008 and in accordance with the 2002 Energy Development Strategy, the MMRE advertised the CHP5 as a Build-Operate-Transfer (BOT) project open to foreign investors. However, although the project initially attracted some 20 expressions of interest by companies purchasing the bid documents and related information pack, only one bid was eventually received which was considered to be incomplete and non-compliant with the bid requirements.

391. The reasons for the lack of bids and the failure to implement CHP5 using the BOT modality have been discussed with various project stakeholders and include:
- Poorly prepared bid documents that were not comprehensive and made it difficult for bidders to fully assess the risks they might have to bear.
- The lack of previous experience in the application of BOT contracts in Mongolia,

and therefore an uncertain regulatory environment.

- A lack of clarity in how a BOT concession would be recognized under Mongolian law.
- The fact the energy sector was reliant on government subsidies and a lack of clarity over what financial incentives and guarantees were available to the successful BOT contractor.
- It will be important that any future PPP bid takes account of these factors, to the extent they remain relevant in any new PPP procurement exercise.

392. However, since the failed bid, the financial position of the energy sector has improved as a result of tariff increases in 2008, 2009, 2010 that have reduced (but not eliminated) the sector’s requirement for government subsidies, which are set to reduce further as a result of recently announced 2011 tariff increases. In addition, the Mongolian Law on Concessions has been enacted to create greater legal certainty. The level of foreign investment in Mongolia generally has also increased rapidly, especially in the mining sector.

3. The Mongolian Law on Concessions

393. The Mongolian law on concessions was enacted and became effective on 1st March 2010. The law includes provisions that:

- Formally recognize concession contracts with private companies as a legitimate means to deliver public services and exploit natural resources;
- Identifies the forms of contracts that are to be considered as concession contracts under the law;
- Creates a procedure for the conceptual approval to let a concession and defines the approval process for this;
- Establishes a procedure for the bidding, bid evaluation and negotiation of concession contracts;
- Assigns responsibilities for administering the law, the procurement and approval of concessions; and
- Establishes a PPP and Concessions unit within the State Property Commission to coordinate the implementation of the law (and to thus become a center of excellence in the structuring and procurement of such contracts).

394. However, as the new law only came into effect in March 2010, it is too early to assess whether or not it will be fully effective in providing the greater legal certainty needed for the successful application of concession contracts. Indeed, as yet no concessions have been let under the new law, but a large number of possible concessions (in excess of 120) have been identified and a schedule of intended PPP contracts, which includes CHP5, has been approved by the Cabinet.

4. Initial ADB support to Develop a PPP Solution (July to September 2010)

395. As a precursor to the full CHP5 feasibility study being undertaken under the TA, ADB asked Denzel Hankinson of Castalia Strategic Advisors to identify options for implementing CHP5 as a public private partnership (PPP project), based on international practice and the unique country and sector context in Mongolia. In order to discharge these responsibilities, Mr. Hankinson made two trips to Mongolia in July and September 2010. During the second of these visits he worked closely with the TA team and subsequently submitted his report in October 2010.
This preliminary work was commissioned by ADB in view of unforeseen delays in mobilizing the main TA, and recognition of both the urgency of the CHP5 project and the long timescale in designing, procuring and closing a suitable PPP contract. The objectives of this preliminary work were to provide:

- A preliminary analysis of the environment for implementing PPP contracts in Mongolia (in terms of contract design, procurement and subsequent regulation);
- Identification and initial comparison of financing options for CHP5;
- Presentations of options to local stakeholders as well as key issues that need to be addressed in the successful design and implementation of PPP in the power sector based on international experience; and
- Suggestions on how to improve the prospects for a successful PPP for the CHP5 project.

Thus the Castalia work dovetails closely with the PPP work within the TA and our approach has therefore been to draw on this work and further develop it during the TA. The conclusions of this work can be summarized as follows:

- The most internationally common types of PPP for new power plants — Build-Operate-Transfer (BOT) and Build-Own-Operate (BOO) — are good options for CHP5 as long as the arrangement also allows for the use of some concessional financing or guarantees to help reduce the overall cost of the plant and mitigate the amount of increase in energy tariffs required to attract investors.
- A well-designed PPP for the financing and implementation of CHP5 is preferable to traditional public procurement and financing.
- A full concession type of PPP with an extensive transfer of risk, would be the preferred model to adopt for CHP5. Thus the report endorses the use of the BOO model as proposed by the PPP Unit of the State Property Commission.
- In the detailed design of the PPP for CHP5 it will be important to try and mitigate against the two inherent disadvantages of PPPs
  - The cost of capital incurred is higher than with projects financed by government borrowing (and especially so where the Government has access to concessionary finance, such as ADB, WB, or JICA loans).
  - The long PPP contract design and procurement period, which is typically two years or more, but may be shortened in favorable circumstances.
- Lessons should be learned from experience elsewhere in Asia, including the mitigation of the PPP disadvantages referred to above.
- CHP5 provides an ideal opportunity to test the operation and effectiveness of the new Concession Law and gain first-hand experience in the procurement and management of PPP contracts. In this regard the need for relevant capacity building and expert advice is emphasized, as a means of mitigating the lack of PPP experience in the Government.

The TA team undertook a detailed review of the Castalia report and was also involved in some of the discussions with stakeholders, and formulation of the preferred approach prior to its preparation. As such, the TA team concurs with the main findings of the report and considers it provided a solid foundation on which the detailed design work of the CHP5 PPP can be undertaken.
CHP3 site is the most suitable location for CHP5 by undertaking a comprehensive remodeling and upgrading of the existing CHP3 facilities. This approach was discussed at tripartite workshops held in December 2010 and March 2011 and was broadly endorsed. However, it is apparent that some local experts and politicians believe the high-pressure system of the existing CHP3 plant should be retained and incorporated into the new CHP5. It is understood this view results from the significant investment that was made in the CHP3 facilities only some 10 years ago.

400. The retention of the old CHP3 high-pressure system would increase the “brownfield” characteristics of the CHP5 project, as well as its overall complexity, and reduce the scope for the potential innovations that a PPP contractor could deliver. Thus the CHP5 project is now potentially a very different one from the project that appears on the cabinet approved PPP listing (which assumed the use of a Greenfield site). In the light of these developments the benefits of PPP could be somewhat reduced and the PPP itself would be a more complex one contractually. Nevertheless, a PPP form of financing is still considered to be feasible.

C. A Suggested Possible PPP Structure for a BOT or BOO in Mongolia

401. The Castalia report utilized the analysis of PPP strengths and weaknesses in the context of the then current status and circumstances of the CHP5 project, and also drew on international case studies in three developing countries in Asia (the Philippines, Vietnam and the PRC) to introduce a conceptual model that might be used as a rough template for a BOT or BOO for CHP5. Figure 10.1 shows this possible contractual structure of a BOT or BOO for CHP5.

**Figure 10.1: Possible Contractual Structure of a BOT or BOO for CHP5**

402. The figure shows the Government entering into a BOT or BOO contract with a private concessionaire. The private concessionaire would be a special-purpose company (“CHP5 Company”) created to be the Government’s private counterpart in the BOT contract. It is common for this type of special purpose company to be owned by a group of several...
shareholders, at least some of whom have expertise in infrastructure projects similar to the one being carried out. The CHP5 Company would have a Power Purchase Agreement (PPA) with the Central Electricity Transmission Grid Company (CETG) and a Heat Purchase Agreement (HPA) with the UB District Heating Network Company (UBDHN). CETG and UBDHN would then sell the electricity and heat to the distribution networks, who in turn sell it to customers as happens now.

**Figure 10.2** shows the possible financial flows of a BOT or BOO arrangement for CHP5.

**Figure 10.2: Possible Financial Flows of a BOT or BOO for CHP5**

403. Under a BOO or BOT, the private concessionaire would raise all of the capital to finance the construction of the plant. Some percentage of the capital costs (typically in the 20 to 30% range) would be funded by equity contributions from shareholders of the private concessionaire, and the remainder would be financed by project-based debt. Debt would be raised from commercial lenders or the private lending arms of multilateral development banks such as the International Finance Corporation or the Asian Development Bank. It would likely be raised on a project finance basis under a single loan agreement with a syndicate of banks.

404. The general analysis of the benefits of PPP and the generic contractual structure provided in the Interim report was mainly based on a Greenfield PPP. It is now most likely that CHP5 will be constructed on the CHP3 site and make optimum use of existing CHP3 assets. If it is decided that PPP is the best way to finance CHP5 then the resulting PPP will have a mix of “Brownfield” and “Greenfield” characteristics. It is suggested the cleanest strategy for implementing a PPP in these circumstances would be as follows:

i) The existing state-owned CHP3 generation company becomes the CHP5 company in the suggested contractual model shown in Figure 10.1.

ii) The PPP contractor takes a controlling interest in the existing CHP3 company, which then transitions into the CHP5 company as shown in Figure 10.1. In effect potential PPP contractors would be invited to bid for the existing CHP3 company assets with an obligation to construct the CHP5 plant to a minimum required output specification and within a prescribed timescale.
iii) Government retains a minority interest in the CHP3/CHP5 Company

iv) The CHP5 company should inherit existing operating licences and contracts held by the CHP3 company. The CHP5 company should be entitled to retain revenues, whilst being required to discharge the various obligations of those existing contracts.

v) The CHP5 company should be free to decide which existing CHP3 assets are retained and which are dispensed with, subject to required regulatory approvals.

vi) The PPP should cover both the Phase I and Phase II construction of CHP5, as it would be almost impossible to independently implement the Phase II project without the involvement of the CHP5 contractor:

405. We believe the above strategy would be a practical approach to implementing CHP5 by PPP using a BOO form of contract as currently identified on the Government’s initial list of PPP projects. However, the approach now proposed does significantly complicate the PPP relative to a pure “Greenfield” PPP and would undoubtedly lengthen the design and procurement of the PPP.

D. An Alternative Financing Strategy

406. An alternative strategy to the financing of CHP5 would be to defer the use of PPP until the second phase of the project, using public procurement for the first phase. This would involve:

- Government financing and implementing the first phase of the CHP5 project using an engineering, procurement and construction (EPC) form of contract incorporating appropriate performance guarantees;
- Once Phase I was commissioned, the entire CHP3 asset would then be sold to a PPP contractor who would both take over operations of the plant and also be required to finance and build the Phase II.
- Preparations for the PPP could be made in parallel with implementation of Phase I

407. The potential advantages of this approach are that:

- Procurement and the commencement of Phase I implementation would be speeded up as long as government could arrange the necessary funding.
- Financing costs for Phase I would in all probability be lower.
- Government would recoup its investment made in Phase I (unless the PPP unexpectedly failed – something we believe is unlikely if it is properly planned with expert advice).
- Simpler more straight-forward PPP projects would be the PPP pilots in Mongolia, giving a potentially lower risk path for the implementation of government policy on PPP and private concessions, and when the CHP5 PPP was procured there would be more of a local track record of such contracts.

408. The potential disadvantages of this approach are that:

- The benefits of private sector innovation and efficiency savings would be lost during Phase I potentially increasing life-cycle costs
- The Phase I design would potentially constrain the PPP contractor’s scope for innovation and efficiency in Phase II.
- Government has to arrange Phase I financing.
Public financing seems to go against, or at least delay, that part of the government’s energy strategy that calls for greater private sector participation.

E. Other Issues

1. Allocation of Risks

One of the benefits to Government derived from the use of PPP is that significant levels of risk can be transferred to the private sector partner. The allocation of risk between the Government and PPP contractor is an important aspect of PPP design and international experience shows that this allocation can often have a strong influence over the success of the PPP arrangement. The “best practice” approach to risk allocation (ie the approach shown to give the best outcome to the PPP from the perspective of both sides) is that the party best able to manage or influence a risk should bear that risk.

Of course, where Government is an equity stakeholder in the PPP project company (ie the JV model of PPP is used) then Government will bear part of the risk that would be transferred to PPP contractor if a full PPP model were to be used.

In Appendix 6, Table 5, we have provided a schedule of potential risks identified for the CHP5 project and indicates the probable allocation of these under the suggested PPP structure and also for traditional public procurement using an Engineering–Procurement-Construction (EPC) form of contract.

2. Mitigating the Higher Financing Costs of a PPP

One of the disadvantages of PPP is that the financing costs for a PPP contractor are almost inevitably higher than those of a sovereign government. It is therefore important to try and mitigate these higher costs.

As indicated in the Castalia report, public financing and concessionary financing could be harnessed to reduce project financing costs and with them, the tariff. More specifically, it identifies ways to reduce total project costs as follows:

- Government financing for certain capital works;
- Partial government ownership of the special purpose vehicle;
- Guarantees from the development banks; and
- Lower cost financing from donors’ private-sector arms.

These approaches are discussed in greater detail in Appendix 6 and it will be noted our suggested PPP structure provides for partial government ownership. We also believe that the PPP contract should exclude all works outside the actual CHP5 site. Thus government should construct the new heating pipelines and any required strengthening of the electricity transmission grid etc under separate contracts via public finance (assuming the electricity and heating distribution companies have insufficient financial capacity to do this themselves).

3. PPP procurement

The TA terms of reference request the Consultant to make recommendations on the bidding process to be followed for a PPP. Specifically the questions asked are whether there should be pre- or post-qualification, whether one stage or two stage bidding should be adopted and whether financial proposals should be requested along the technical submissions. Whilst the question is not specifically asked, it is assumed that the procurement would be undertaken by international bidding, as it is clear there is no local
capacity to undertake such a large project of this complexity.

416. These procurement options are discussed in Appendix 6 on the assumption that the over-riding objective of the procurement process is to select a suitable private sector partner (contractor) that is technically competent and offers value for money. It is also important that the procurement process is carried out as expeditiously as possible and that the procedures addresses the common concerns of potential bidders.

417. Based on the analysis provided in Appendix 6 we believe the optimum procurement process would be to use two-stage bidding with post qualification undertaken during the first stage evaluation, and for final bids to include detailed financing plans.

4. Policy, Legal and Regulatory Arrangements

418. The TA team has reviewed the existing policy and legal framework and the current regulatory arrangements. In particular we have examined:

- Government energy policies and strategy
- The energy law
- Other relevant laws (environmental law, public procurement law, law on foreign investment, concession law, law on anti-corruption etc)
- The role and operation of the ERA

419. We conclude from this review that the legal, policy and regulatory environment is generally favorable for the use of PPP and no major constraints that might impede the use of PPP exist. The ERA as the energy sector economic regulator seems to be professionally competent, adequately staffed, and in theory at least, is independent of the MMRE and government. Foreign investment and anti-corruption laws appear to adequately protect and give suitable assurance to foreign investors.

420. However, whilst the legal framework is generally favorable, it is new and completely untested as no major PPPs have yet been implemented in Mongolia. The principle regulatory concern of potential PPP contractors will undoubtedly be the lack of a PPP track record and how the laws will be interpreted and enforced in practice. Some specific concerns that a PPP contractor may have are identified and discussed in Appendix 6. These are the risks (i) of “regulatory capture”, (ii) current tariffs mean the energy sector is currently reliant on government subsidies; (iii) the interpretation of rules used for power draw–off; (iv) use of short term PPA; and (v) a possible liability for the costs of employee redundancies.

5. Project Management and technical assistance

421. The implementation of CHP5 whether by PPP or by traditional public procurement will require a high level of project management, effective coordination between government departments, and consultation with affected parties. We assume the existing project implementation unit (PIU) established within the Energy Authority under MMRE will remain responsible for coordinating implementation activity, but it will undoubtedly require additional resources and expertise in order to carry out this task in an effective manner.

422. We consider an early action should be to set up a multi-disciplinary project team under MMRE leadership with representatives from all concerned ministries and Agencies, as well as from UB city government. This project team should oversee the procurement process (whether by PPP or a government financed EPC contract).

423. As the government is currently inexperienced in the implementation of PPP it will be essential for suitably qualified foreign technical advisors to be appointed to work with and
advise the PIU and the project team. This advisory team should be appointed as soon as possible after firm decisions are reached to (i) proceed with CHP5; and (ii) the preferred method of financing. The advisory team would need to be retained throughout the procurement period until the PPP contract is finalized.

424. The core members of the advisory team would be:

- A PPP procurement specialist (15 months input over a period of up to two years);
- A power engineer with previous PPP experience (up to 12 months input);
- A financial analyst (up to 6 months input).

425. The advisory team would need to be supported by Mongolian experts including local legal, procurement, technical and financial specialists.

F. Initial Conclusions

426. Based on the analysis in this section of the report and Appendix 6, our conclusions on the possible use of PPP for the CHP 5 project are set out below:

1. **Rationale for the use of PPP**

427. The Government’s rationale for the use of PPP includes:

- A reduced need for government capital investment
- Leveraging the experience of a private sector contractor in design and construction (improved construction efficiency and quality);
- Leveraging the experience of the private sector in CHP operations
- PPP is consistent with a phased commercialisation of the whole energy sector in accordance with the Government’s Energy Strategy.

2. **Advantages and Benefits from Using PPP**

428. Important potential advantages for the PPP approach are:

- PPP can transfer significant risks to the private sector, such as construction cost and construction delay, which the private sector is better able and has greater incentive to manage.
- PPP is more likely to ensure a life cycle view of costs is taken at project design stage and to encourage innovation in design, construction and operation.
- A PPP approach would be compatible with the new Concession Law and political objectives to encourage greater private sector involvement in the construction and operation of public infrastructure.

429. Not all PPP approaches offer the same opportunities and incentives to realize these potential advantages. The DBOF-type PPP structures (including the BOO ROO approach preferred by the SPC’s PPP Unit) appear more suitable PPP models for CHP5 than the other types of PPPs (such as design build (DB) and design build operate (DBO)). This is principally because DBOF will lessen the initial financing burden on Government and creates an incentive for the PPP contractor to take a long term view to minimize life cycle costs.

3. **Potential Problems that would need to be overcome**

430. Difficulties with the use of PPP for the proposed CHP5 project are:

- Lack of a Previous PPP track record in Mongolia
Reconciling the timescale required for a PPP procurement and contract closure with the target CHP5 implementation commencement set by Government. This inherent difficulty is undoubtedly exacerbated by the lack of any PPP track record in Mongolia and in government PPP capacity.

The cost of capital to a BOO/ROO contractor is inherently higher than sovereign loans taken out by government, and quite significantly higher than concessionary finance that might be available from multi-lateral or bi-lateral donor agencies (ADB and JICA funding has been mentioned in some stakeholder discussions). The higher cost of capital would put greater upward pressure on energy tariffs, especially as financing costs will be a significant part of the total CHP5 investment.

A full PPP approach is likely to exacerbate the need for a “front end loading” of tariff increases, because a strong early cash flow will be an expected requirement of the PPP contractor. This could be mitigated via transitional government subsidies or other forms of financial incentive (if these can be assured).

The project has become a mix of greenfield and brownfield features. Whilst the BOO model of PPP remains fundamentally sound for such a project it would need to be adjusted to include some features and terms seen in the Rehabilitate, Own, Operate (ROO) model of PPP.

Capacity building needs for the MMRE, PPP unit and other Government agencies.

Current tariffs fail to fully finance the power and heating sectors.

ERA has only limited regulatory experience in regulating private sector operators.

Uncertainty created by possible energy market reforms.

It must be emphasized that none of these potential obstacles rule out the use of PPP but are difficulties that must be considered and managed in the process of designing and implementing the PPP. In some cases action is already being taken – for example ADB is providing technical assistance to the PPP unit of SPC to help build their capacity to manage PPP procurement, and also plans have been drawn up for a series of tariff increases over the next two years, with the 2011 increase recently approved and made public.

If PPP was to become the preferred procurement method for CHP5 then we believe the generic BOO model of PPP should be used, modified to take account of the projects particular features. In this situation, our suggestion would be that the existing CHP3 company should become a PPP joint venture company, and be the implementation vehicle for the project.

4. The Phasing of CHP5 Construction

The power and heat demand estimates for Ulaanbaatar over the period through to 2020 suggest that construction of CHP5 should be a facility of total generating capacity of 820 MW, but implemented as two separate phases with Phase I of 450 MW and Phase II of 370 MW. This raises the issue of whether the PPP should be designed to cover both phases or just the initial phase. The degree of interdependence between the two phases (e.g. sharing of common facilities, staff and operating systems) suggests it would be almost impossible to segregate the facilities. Therefore the PPP should be procured for the whole facility (i.e. both phases).

5. Alternative Financing Strategies

Based on the analysis in this report, our conclusions on the possible use of PPP for the CHP5 project are set out below: As discussed in above alternative strategy to the financing of CHP5 would be to defer the use of PPP until the second phase of the project, using public procurement for the first phase and then selling the CHP5 facilities to a PPP
contractor, who would then operate them and construct the Phase II plant.

435. The second alternative would be to construct both phases using traditional public procurement. However, this approach seems to run contrary to the energy strategy and government objectives to increase private sector investment. It would also tie up a significant amount of government finance and prevent this from being used for other purposes.

6. Concluding Thoughts

436. We consider that use of PPP for CHP5 would deliver some important benefits, but also that the urgency of the project, its increasing complexity now that use of the CHP3 site has been selected, and the lack of PPP experience in Mongolia are major concerns that increase the risk of the PPP being unsuccessful or encountering delay. After careful consideration, we believe it would reduce project risk if traditional public financing of CHP5 were to be adopted for the Phase I construction and then PPP adopted for Phase II by transferring the Phase I assets to a PPP contractor.

437. However, if public financing is not considered appropriate for any reason, and a decision is reached to proceed with PPP financing then Government can maximize the prospects for a successful PPP by taking the following steps in the PPP design that mitigate the PPP contractors risk in areas they may feel they lack control:

- Exclude supporting infrastructure located outside the selected CHP5 site from the scope of the PPP;
- GoM gives assurances (or better still guarantees) in respect of the minimum level of power and heat take-off from the CHP5 facility.
- The PPP contract allows for settlement in the PPP contractor’s nominated foreign currency which transfers the foreign exchange rate risk to GoM.
- GoM gives assurance over the “freedom of design” flexibility to be given to the PPP contractor (subject to the PPP contractor giving performance guarantees over output, reliability and environmental standards)
- GoM gives assurance over the availability and price of coal to be paid by the PPP contractor.
- GoM gives assurance over the availability of water supply up to a certain level.

438. In addition, GoM should:

- Offer to be a joint venture partner in the PPP (but not insist).
- Facilitate CHP5 company’s access to concessionary finance.

439. Expedite the setting up of a multi-disciplinary project team for CHP5 implementation and the appointment of technical advisors.
XI. ECONOMIC EVALUATION

440. Mongolia faces bright prospects and critical challenges, and a modern power and heating plant for the capital city is an unquestionable necessity as demonstrated in Sections IV and V of this report. All stakeholders realize this is not a choice or luxury but a pro-poor imperative. Well-off citizens and organizations will find ways, even if expensive, to enjoy power and heating. The new CHP 5 will serve the expanding modern industries and a wider public, and at the same time abate the serious pollution issues which would otherwise stifle society and harm health of residents of UB.

A. Background

441. The nation has experienced strong growth of economy, population, and now has high consumption expectations. Most recent estimates suggest Mongolia’s GDP grew 6.1% year-on-year in 2010. Large scale mining activity and buoyant mineral prices will lead to sustained development in the foreseeable future. Inflation is in double digits, 14% and 12% for December and November 2010 respectively, and this impacts on the energy sector. Also, the rising price of food will affect consumer household’s ability to pay for power and heat. Food produce supply has been severely affected by local extreme weather conditions, and exacerbated by similar problems neighboring Chinese food supply bases. Possibly one fifth of Mongolia’s domestic animal herd have been killed in recent extreme weather – blizzards, preceded by drought.

442. Current estimates are for an annual increase in both electricity and heating demand of 4-5% up to 2020. There was a major opening up of the energy sector in 2001, creating 18 companies accountable individually, though still under state control, and necessarily subsidized to deliver the required power and heat. The current project is mandated to evaluate feasible ways of connecting the new CHP plant to the power grid and heating network. During the TA period, the theoretical supply capacity of the plant has been estimated to be 820 MW power and 1,281 MWt (1,101 Gcal/hr) heat.

B. Demand Forecast

443. Demand of power and demand of heating are spread over areas that are very different in size and nature. The demand for power includes all of the CES, with CHP5 contributing with other plants to the grid. The demand for heating is limited mainly to the modern urbanized city blocks of UB, currently serviced by three existing CHP plants and many HOBs.

444. The total heating capacity for the CHP5 plant is estimated to be 587 MWt (504 Gcal/hr) by 2015 and 1,281 MWt (1,101 Gcal/hr) by 2020 upon the full operation of the CHP5 plant and the retirement of the existing CHP2 and low pressure system of CHP3.

445. The total power demand of the CES is forecast to be 1,313 MW by 2015, and 1,728 MW by 2020. Due to the fact that CHP5 is mainly designed to meet the heat demand as mentioned above, it will not fully meet the additional power demand of the CES system. The power supply of the CHP5 is proposed to be 450 MW by 2015, and 820 MW by 2020. The remaining power demand will be covered by other power sources.

33 World Bank Mongolia Quarterly Economic Update, January 2011.
34 World Bank Mongolia Quarterly Economic Update, January 2011
35 T. Enkhtaivan, Vice Minister, MMRE, 2010, Current Situation, Problematic Issues and Further Implementation Objectives of Energy Sector
C. Least-cost Analysis

446. To meet the demand set out above three alternative scenarios were studied. It was assumed that CHP2 will certainly be decommissioned. CHP3 also only contributes 17.5% of power and about 35% of heat (it was commissioned 1968). Furthermore, earlier documents mooting the scenario of a new CHP5 at 300 MW for demand in 2015 are now superseded by this TA study. Thus the essential scenario to meet 2020 demand seems to be supply from the existing CHP4, together with a new CHP5 of 820 MW capacity. Given that CHP3 is of an old design, it is proposed that CHP5, with high efficiency and low emissions will negate the need for CHP3 low pressure system after 2015 (CHP3 HP system will continue to be utilized).

447. The core decision has been made to choose as the best possible scenario a design to build a first stage CHP within the boundary of the existing CHP3, then demolish the low pressure system of the CHP3 and build the second stage in its place to complete the new CHP5.

448. This least-cost analysis adopts data generated by the financial analysis for the establishing of a 820 MW CHP5 plant commissioned in two stages: the first 450 MW by 2015 and the remainder by 2020.

449. Comment is made that from ADB 1997 Guidelines for the Economic Analysis of Projects, financial and economic costs may differ. In this project, the financial cost of coal, transport of coal, water and land are all accounted for in this economic analysis. In economic analysis they are more than the direct monetary costs listed in the financial analysis. The non-direct costs to society are addressed in this analysis in the EIRR. The non-direct benefits to society are also included in the EIRR.

D. Valuation of Economic Costs and Benefits

450. The economic costs and benefits need to be compared in a single numeraire for fair assessment. The benefits can be entirely quantified in MNT, and so can much of the costs, though it is presumed core equipment of boilers, turbines and generators will be imported, paid for in some foreign currency.

451. The financial costs of the new CHP 5 plant, as set out in the Finance Analysis section (Section IX), are presented entirely in 2010 MNT and estimated to total 1,878,823.8 million MNT for years 2013-2042, of which capital costs will be in two tranches of 3 years each, each totaling 939,412 million MNT.

452. In U.S. dollar terms, the capital costs for the 820 MW CHP is about $1349.5 million, which is in the ambit of expected power station costs in a developing country, or one-half to two-thirds of costs in a developed country.

E. Economic Costs Beyond Actual Financial Costs

453. The ADB Guidelines for the Economic Analysis of Projects sets out the definition of an Economic Cost as consisting of two parts: the economic cost of the incremental quantity demanded and the economic cost of the non-incremental quantity demanded. The analysis of the CHP5 Project identified four items where the economic cost must be imputed to be higher than the listed financial cost, namely, coal, transport, water and land.

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1. Coal Cost

454. The 3.63 million tons of coal required annually will come from Baganuur (approximately 30%) and Shivee-Ovoo (approximately 70%). The current prices are 18,190 MNT/ton and 14,000 MNT/ton respectively. Both mines have been operating in losses for years. At a coal mine price equivalent to $14/ton and $10.70/ton respectively, there is clear evidence of subsidies. A realistic price figure reflecting actual economic costs, and with no hidden subsidies was chosen as $30/ton (39,000 MNT/ton). This is in line with market price at mine front gate for coal mined in Shanxi Province in similar inland conditions.37

2. Transport Cost

455. The transport costs of coal used in financial analysis are 3,200 MNT/ton and 4,000 MNT/ton from Baganuur and Shivee-Ovoo, respectively. The rail distances to the plant from these two mines are approximately 130 km and 260 km, respectively. These costs too are subsidized and a range of calculations resulted in deemed economic costs of 3,400 MNT/ton and 4,700 MNT/ton.

3. Water Cost

456. Conventional economics originally claimed water to be free because it was in abundance. That certainly must be revised in modern economy, certainly in land-locked and dry Mongolia. The World Bank quotes the water tariff in UB to be MNT1,000/m3.38

4. Land Cost

457. The financial analysis lists costs for relocating 9 entities from new acquired 2.5 hectares of land. This Economic Analysis estimates the opportunity cost of the entire 88 hectares of the old CHP3 plus the new 2.5 hectares. The existing 88 hectares of site cannot be passed off as zero economic value, yet it is difficult to imagine clearing and then marketing the site anew. Given that the additional 2.5 hectares of land has been expertly valued at US$1.8 million, the existing site is assigned a value of $500,000 per hectare.

F. Economic Benefits Beyond Actual Financial Revenue

1. Consumer Surplus

458. The ADB Guidelines for the Economic Analysis of Projects sets out the definition of a consumer surplus over and above gross revenue39. Consumers of electricity face a structured set of tariffs depending on whether they are households, industry, or public service, plus other conditions. The gross revenue is simply the tariff price multiplied by the number of consumers in each category. At the margin of consumer demand there are poorer consumers barely able to afford the tariff. Yet there are many more, in UB, maybe a hundred thousand, who enjoy the set tariff and in fact would pay more if required. This benefit enjoyed for free is estimated for electric power to be 25% above actual gross revenue, and for heating to be 45% above actual gross revenue. As a crosscheck on these estimates, consideration was given to the

37 Ezinemark 18 October 2010.
39 Guidelines for the Economic Analysis of Projects, Economics and Development Resource Center, ADB, 1997 p 62 Figure 1.
costs to be paid if more electricity was imported from Russia, and if some of the heating was done in inefficient HOBs and even individual stoves. A substitute to be used if CHP heating was not supplied can be a 15 kg sack of coal, which is burnt in one day in a home (80% heating, 20% cooking) and costs approximately 1300 MNT. Estimating the calorific value of a sack of coal used in one day as 40,000 kCal, this is about five times the tariff charged by CHP plants for heating (namely 7,430 MNT per Gcal). It should not be underestimated just because this is hard to quantify, but the modern CHP5 is clearly a pro-poor project ideally in line with the heart of the ADB mission statement. The concept of consumer surplus benefit, beyond the actual tariff paid, is graphically illustrated in the ADB Guidelines for Economic Analysis of Projects, and reproduced and annotated in Figure 11.1.

Figure 11.1: Consumer Surplus from ADB Guide withAnnotations for UB

2. Economic Benefits to Health

Beyond the direct economic benefits mentioned above are those accruing to the residents of UB from cleaner air, as manifest in reduced health cost and improved labor productivity. Considerable research and surveys have been conducted in many countries, and the data for north China is useful indicatively. The report refers to studies around the world of Value of Statistical Life and its link to per capita GDP. Cost of hospitalization of sufferers of bronchitis, cardio-vascular disease, and respiratory problems caused by air pollution are estimated. Though Mongolia is not mentioned, the approach is methodical and

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40 Guidelines for the Economic Analysis of Projects, Economics and Development Resource Center, ADB, 1997 p 62 Figure 1
was subsequently used the 2009 surveys in UB. In 2009, the World Bank conducted extensive research on air pollution in UB, reporting alarming excesses of air pollution, especially in harmful particulate matter (PM), mainly from coal combustion. After conservative calculations the World Bank study concluded that in 2009 total health care costs incurred by air pollution would be $74 million. An upper figure stated was $147 million. The study noted that the three CHP plants in UB had stacks between 150-250 meters high, and so most PM from them was carried away from the population. Yet one impact is that insufficient heating from the CHPs drove the use of more HOBs and household stoves, and here the impact caused hundreds of mortalities, bronchitis, and hospitalized respiratory problems. Therefore, in this Economic Analysis, it is conservatively estimated that a new efficient CHP, and the closing down of older CHPs, together with closing down most HOBs and the avoidance of bringing on new ger stoves, can reduce total health costs by $10 million annually. The early years are prorated commensurate with increasing coal consumption. It is noted in the WB survey that a Willingness-to-Pay for avoidance of premature death was settled at $200,133. Using this imputed value of a healthy life in UB, the saving of $10 million per year is justified. As an indication, the health incidents to be avoided by a 50% reduction of ger stoves and HOBs are shown in Table 11.1.

### Table 11.1: Annual Number of Cases Avoided by Pollution Reduction

<table>
<thead>
<tr>
<th></th>
<th>All-cause mortality (chronic)</th>
<th>Chronic bronchitis</th>
<th>Hospital admissions (respiratory disease)</th>
<th>Hospital admissions (cardio-vascular)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% ger stoves</td>
<td>149</td>
<td>121</td>
<td>277</td>
<td>170</td>
</tr>
<tr>
<td>50% HOBs</td>
<td>31</td>
<td>28</td>
<td>65</td>
<td>40</td>
</tr>
</tbody>
</table>


3. Impact on Tourism

The number of international tourists visiting Mongolia is increasing rapidly and amounted to 400,000 in 2009, and the industry represents about 10% of GDP. There are over 250 tourist companies catering for international visitors. No study was uncovered of how polluted air over UB may affect tourist business, but it can be assumed to have some significant effect, especially as a proportion of tourists are attracted by nature and ecology. It can be assumed that word-of-mouth reports by returning tourists would have some influence on decisions to visit Mongolia. One report of relevance to the concept was a study of tourism in Ireland and the environmental efforts and costs needed to maintain its “green image.” A value of $1 million per year is assigned to positively supporting the tourist industry by having cleaner air and bluer skies over UB as the old CHPs and HOBs are phased out. The first early years are prorated commensurate with increasing coal consumption.

G. Evaluating Results and Analysis

The Economic Internal Rate of Return (EIRR) for the CHP5 plant on the old CHP3 site was calculated for the years 2011-2042, based on the financial costs and revenues, together with imputed economic costs balanced by additional indirect benefits. The economic costs imputed beyond direct financial data were for of coal, coal transport, water and land. The additional economic benefits to society estimated were consumer surplus for power and for heat, the benefits of costs avoided by improved health environment, and benefits to commercial tourism. The result of EIRR calculations for the CHP5 Project is 20%, as shown in Table 11.2.

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### Table 11.2: EIRR of CHP5 at CHP3 Site (million MNT)

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Cashflow</th>
<th>Net Indirect Economic Benefits</th>
<th>Net Economic Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>-213,888</td>
<td>-57,200</td>
<td>-271,088</td>
</tr>
<tr>
<td>2014</td>
<td>-190,487</td>
<td>32,758</td>
<td>-157,729</td>
</tr>
<tr>
<td>2015</td>
<td>31,875</td>
<td>128,840</td>
<td>160,715</td>
</tr>
<tr>
<td>2016</td>
<td>32,550</td>
<td>128,298</td>
<td>160,848</td>
</tr>
<tr>
<td>2017</td>
<td>-152,961</td>
<td>151,920</td>
<td>-1,041</td>
</tr>
<tr>
<td>2018</td>
<td>-211,092</td>
<td>183,987</td>
<td>-27,105</td>
</tr>
<tr>
<td>2019</td>
<td>-129,448</td>
<td>207,655</td>
<td>78,207</td>
</tr>
<tr>
<td>2020</td>
<td>86,609</td>
<td>299,325</td>
<td>385,934</td>
</tr>
<tr>
<td>2021</td>
<td>86,609</td>
<td>294,895</td>
<td>381,504</td>
</tr>
<tr>
<td>2022</td>
<td>105,324</td>
<td>290,464</td>
<td>395,788</td>
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<tr>
<td>2023</td>
<td>105,324</td>
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<td>105,324</td>
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<td>373,637</td>
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<tr>
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<td>105,324</td>
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<tr>
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<td>105,324</td>
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<tr>
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<tr>
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</tr>
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<td>175,035</td>
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<td>116,592</td>
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<td>2036</td>
<td>59,866</td>
<td>114,376</td>
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</tr>
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<td>28,089</td>
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</tr>
<tr>
<td>2041</td>
<td>28,089</td>
<td>34,217</td>
<td>62,306</td>
</tr>
</tbody>
</table>

**EIRR**  
20%

*Source: TA Team estimates.*

462. Clearly and logically, a modern CHP plant for UB has vital non-monetized economic benefits, and the city, its economy and society, could not function without the power and heat provided. As shown in Section IX, the revenue from tariffs cannot of themselves cover costs without substantial tariffs increase, but the broader economic benefits, though difficult to define precisely, justify the CHP5 Project.
H. Impact, Benefits and Risk Analysis

463. UB is fast modernizing, and CHP5 plant is urgently needed, and its commissioning will see CHP2 and part of CHP3 taken out of service. The capital is the commercial and service center of the nation and accounts for 50% of Mongolia’s GDP. It is an understatement to say that a new CHP plant is overdue, with the current three CHP plants now barely meeting demand, and unable to supply expected demand in two to three years, with a consequence of citizens having to turn to inefficient small scale power and heat sources.

464. The ERA is vitally aware of the risks that will be incurred if power and heating cannot be supplied, and if tariffs cannot be responsibly managed with gradual increases. There are lessons to be observed from other cold Central Asian economies where tariff increases have caused major difficulties, and the ERA has taken note. It will be vital for consumers across the range of households and industry to be well-informed of the necessity for tariff increases. A public relations campaign may help to encourage responsibility in energy efficiency, and to educate citizens on the real costs of energy.

465. Mongolia is currently well-positioned with international reserves in the Bank of Mongolia at $2 billion\(^{44}\) in December 2010 though the fiscal deficit is now running at 9.9% of GDP. The exchange rate against the dollar is stable. There are dangers ahead as the dollar devalues against many currencies, and Mongolia’s currency is also in double digit inflation. The TA Team covering Finance, Economics, and PPP has worked together with local counterparts to track these potential risks and recommend the best approach within the current and predicted macroeconomic context.

466. A series of sensitivity analyses was conducted to investigate a change of 10%. Changes in exchange rates will influence proportions imported and this can complicate calculations. In the basic analysis when the exchange rate is changed by 10% the EIRR of 20% did not change perceptibly as shown in Figure 11.3.

Table 11.3: Results of Sensitivity Analyses

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Cashflow</th>
<th>Net Indirect Economic Benefits</th>
<th>Net Economic Benefits</th>
<th>-10% Net Economic Benefits</th>
<th>10% Net Economic Benefits</th>
</tr>
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<tbody>
<tr>
<td>2011</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
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<tr>
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<td>2019</td>
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<td>-27,105</td>
<td>-24,395</td>
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<tr>
<td>2020</td>
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<td>78,207</td>
<td>70,386</td>
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\(^{44}\) World Bank Mongolia Quarterly Report, January 2011
<table>
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<tr>
<th>Year</th>
<th>Net Cashflow</th>
<th>Net Indirect Economic Benefits</th>
<th>Net Economic Benefits</th>
<th>-10% Net Economic Benefits</th>
<th>10% Net Economic Benefits</th>
</tr>
</thead>
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<td>108,940</td>
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<td>116,614</td>
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<td>128,275</td>
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<td>58,334</td>
<td>71,298</td>
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<td>2042</td>
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<td>34,217</td>
<td>62,306</td>
<td>56,075</td>
<td>68,537</td>
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</tbody>
</table>

| EIRR | 20% | 20% | 20% |

Source: TA Team estimates.

467. It is incumbent on the economic evaluation to comment on possible effects of climate change and an increase in the incidents of extreme weather. This is already manifesting in 2010, with weather extremes killing one-fifth of Mongolia’s livestock and damaging grain both domestic and imported. Russia was formerly a main supplier and has banned grain exports due to poor harvest. The consequences are high inflation for food and for energy. The environmental impact assessment section (Section VIII and Appendix 4) sets out potential issues and threats which may have high economic costs (flooding, seismic activity) which have been studied and measures recommended.

I. Analytic Conclusion of Economic Assessment

468. The ADB Guidelines for the Economic Analysis of Projects addresses many forms and scales of projects, but the UB CHP5 project is still outside the normal scope and requires special consideration. CHP5 is a dominant project for UB and the nation, planned to supply the major part of the city power and heat, and about half of the entire CES power demand. Its total cost amount, spread over the 2 phase construction, amounts to about a quarter of the nation’s 2010 GDP. Thus the Guidelines distinguishing “incremental” and “non-incremental” outputs has to actually be recast to acknowledge the “lumpiness” of building and operating CHP5. Calculating the EIRR at 20% demonstrates the economic rationality of the project, but given the unique nature of the necessity of power and heating in the coldest capital city in the world, the Guidelines requirement to compare scenarios of “with” and “without” the project automatically dismisses a “without” scenario. The provision of a major power and heat plant
is necessary and the design advocated is the least cost. The Guidelines point out that depreciation rates used in financial analysis may differ from the broader and truer definition, and this is borne out in the example of CHP3, commissioned in 1968 and still functioning. In this economic analysis the depreciation rates used were as in the financial analysis, and no attempt was made to forecast a longer run-down of the capital equipment. But given the conservative 30 year life assumed for financial analysis, there is a higher undefined economic benefit which could be estimated if the rigorous EIRR calculations had not identified acceptable returns.
XII. SOCIAL ANALYSIS AND RESETTLEMENT

469. This social analysis: (i) provides brief socio-economic profiles of Mongolia and the project area of UB; (ii) presents the both the positive and social impacts; and (iii) proposes actions to enhance positive impacts and to mitigate negative ones (included in the resettlement framework and placement framework).

A. Socioeconomic Profiles

1. Mongolia

470. Mongolia is a land-locked country bordering China and Russia. Mongolia is divided into 22 major administrative units comprising 21 “aimags” (provinces) and the capital city of Ulaanbaatar (UB). All are governed by “Khurals,” or elected bodies. An aimag consists of up to a number of “soums” (districts), including the aimag center. Soums in turn are comprised of “baghs” (villages).

471. The 2009 population in Mongolia was about 2.7 million. The population density is only 1.75 persons per km², making it one of the most sparsely populated countries in the world. Out of the 2.7 million people, 1.16 million or approximately 44% are concentrated in UB.

472. Mongolia’s economy has staged an impressive recovery from the steep recession of late 2008 and early 2009. Moreover, the economic recovery is becoming broad-based. Strong demand for copper and coal from China and other countries is fuelling the recovery. The GDP of Mongolia increased from 3.0 trillion MNT in 2006 to 3.6 trillion MNT in 2009, with a 5.7% average annual increase from 2006 to 2009. The real GDP growth for 2010 is estimated to be 6.1% year-on-year.

2. Ulaanbaatar

473. The capital of modern Mongolia, Ulaanbaatar (“Red Hero”), has a history of about 360 years. UB is the coldest capital city in the world; its lowest temperature was -49°C. Since the reform in early 1990s, the population of UB has grown rapidly, mainly due to the migration stream. The population of UB increased from 650,000 in 1998 to 1.16 million in 2010, at an annual average growth rate of 5% during the period between 1998 and 2010. About 63% of the UB population is living in ger areas with poorer infrastructures. The population of UB accounted for 44% of the country’s population in 2010. As the economic center of Mongolia, UB has more than 70% of the total registered business entities in Mongolia and also contributes 50-60% of the GDP of all of Mongolia. UB is subdivided into 9 districts and 121 “khorooos” (subdistricts). The baseline socioeconomic data of UB is summarized in Table 12.1.

Table 12.1: Baseline Data of UB

<table>
<thead>
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<th>Indicator</th>
<th>Unit</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Population &amp; HH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Population thousand</td>
<td></td>
<td>1102.8</td>
<td>1161.8</td>
</tr>
<tr>
<td>Male %</td>
<td>%</td>
<td>49.2</td>
<td></td>
</tr>
<tr>
<td>Female %</td>
<td>%</td>
<td>50.8</td>
<td></td>
</tr>
<tr>
<td>1.2 ger area popu %</td>
<td>%</td>
<td>62.1</td>
<td>63</td>
</tr>
<tr>
<td>1.3 Non-ger area popu %</td>
<td>%</td>
<td>37.9</td>
<td>37</td>
</tr>
<tr>
<td>1.4 Mongolians %</td>
<td>%</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Indicator</td>
<td>Unit</td>
<td>2009</td>
<td>2010</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>1.5 Ethnic minorities</td>
<td>%</td>
<td>15</td>
<td></td>
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<tr>
<td>1.6 Households</td>
<td>number</td>
<td>273.2</td>
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</table>

### 2. GDP & Income & Poverty

<table>
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<th>Unit</th>
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<th>2010</th>
</tr>
</thead>
<tbody>
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<td>2.1 GDP per capita</td>
<td>US$</td>
<td>1,551</td>
<td>2,010</td>
</tr>
<tr>
<td>2.2 Average per capita income</td>
<td>Tugrugs/month</td>
<td>487,093</td>
<td>546,985</td>
</tr>
<tr>
<td>2.3 Poverty incidence</td>
<td>%</td>
<td>26.7</td>
<td></td>
</tr>
<tr>
<td>3. Unemployment rate</td>
<td>%</td>
<td>14.0%</td>
<td>8.9%</td>
</tr>
<tr>
<td>3.1 Male</td>
<td>%</td>
<td>49.2</td>
<td></td>
</tr>
<tr>
<td>3.2 Female</td>
<td>%</td>
<td>50.8</td>
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</tr>
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</table>

### 4. Education

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<td>97</td>
</tr>
<tr>
<td>Male</td>
<td>%</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Female</td>
<td>%</td>
<td></td>
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</table>

### 5. Number of AIDS cases

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<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>No.</td>
<td>13</td>
<td>21</td>
</tr>
</tbody>
</table>

### B. Resettlement and Social Impacts

#### 3. Land Acquisition

474. The expansion of CHP3 may need to permanently acquire 25,000 m² of land from 7 entities and 2 individual households. The construction of the pipelines will be on public land and will temporarily occupy some existing roads/streets. Along with permanent land acquisition, about 5,193 m² of residential and office buildings and 2,930 m² of temporary structures will also be affected.

475. Negotiated land acquisition will be adopted by the Project and resettlement framework (RF) is prepared to guide the planning of land acquisition and resettlement during Project design and implementation. Appendix 8 presents the RF and it has: (i) set appropriate compensations to property losses of entities/individuals resulted from the Project’s land acquisition; (ii) set compensations and assistances to persons and households who will be physically and economically displaced by the Project; (iii) defined entitlements, consultation and participation plan, grievance redress mechanisms; (iv) defined resettlement implementation monitoring and reporting; and (v) made a budget estimation.

#### 4. Employment Opportunities

476. The CHP5 will provide about 648 employment opportunities. In addition to absorb the 300 workers 45 transferred from the low and medium part of the CHP3, it will create an additional 348 positions for UB and for Mongolia as well. Of course, the new positions will mostly be for skilled workers who will be specialized education and training.

#### 5. Project Benefits and Beneficiaries

477. The direct output of the CHP5 Project will be an upgraded CHP in UB. The outcomes will be: (i) secured power and heat supply for UB and (ii) improved air quality. The project will therefore benefit all people living in and visiting UB. The direct and indirect benefits to local residents from improved air quality will be multidimensional and will include (i) improved living environment; (ii) reduced occurrence of air pollution related diseases; (iii) decreased healthcare expenses; and (iv) more and longer out-door entertainment in winter season, etc.

45 About 1/3 of the total employees of CHP3.
The poor will benefit more from improved air quality as they are more vulnerable to diseases and medical expenses.

478. As an effort to reduce pollution and reduce ger area population, UB government has an ambitious plan to gradually settle most of the ger area population to a number of large- and medium-scale residential quarters with district heating. The proposed project by expanding the heating capacity of CHP3, to a certain extent, is supplementary to this plan. Those families who move to the residential quarters will then directly benefit from the district heating of the Project.

6. Gender Impact

479. The CHP5 Project benefits both women and men. Women and children, however, might benefit more from the project as they are more vulnerable to pollution-related respiratory and other diseases.

480. Families of the ger areas which will likely move to the above-mentioned residential quarters in the future will directly benefit from district heating of the Project. Women from these families will not only enjoy improved living conditions, but also be liberated from the burdens of keeping the coal burning stoves for heating and cooking.

C. Summary Poverty Reduction and Social Strategy

481. The proposed CHP5 Project, aimed at reducing air pollution and securing power and heating supply through upgrading an existing Combined Heat and Power Plant is in line with national poverty reduction strategy of Mongolia and the ADB’s Country Partnership Strategy for Mongolia:

   i) An important aim of the Economic Growth Support and Poverty Reduction Strategy (EGSPR) of Mongolia (2004) is to reduce the air, water and soil pollution in large cities and settlements; and


482. This Project, per ADB standard, is classified as general intervention regarding poverty reduction strategy. A standard Summary Poverty Reduction and Social Strategy of ADB is presented in Appendix 9.
XIII. PROJECT IMPLEMENTATION PLAN

483. The CHP5 project implementation schedule has been developed describing all major project implementation activities over a 10-year project implementation period from 2010 through 2020. As scheduled, the project is to be constructed in two phases, including Phase I which is scheduled to be completed by 2015, and Phase II which is scheduled to be completed by 2020. The project implementation schedule covers four major project implementation stages with indicative milestones to ensure that the project is implemented within a planned timeframe: i) project preparation, ii) pre-construction, iii) procurement, and iv) construction and commissioning.

484. The construction season is relative short in Mongolia due to long-winter season. Thus, some tasks must be performed in parallel and well coordinated in order to meet the target of completing Phase I by 2015. The project implementation plan for both Phase I and Phase II are illustrated in Figure 13.1 at the end of this section.

A. Stage 1: Project Preparation

485. Under the project preparation stage, several key project activities are to be undertaken, including completion of feasibility study report and environmental impact assessment impact (EIA) report and obtaining approvals; bidding document preparation for PPP depending on the Government's decision on how to finance the project; bidding process completion and contract awarding; preliminary design and design review; and detailed engineering design.

486. This report covers feasibility study of the CHP5 project and it includes demands forecast, power plant justification, proposed plant size and technology, heat supply system analysis, site selection and surveys, coal analysis, master planning of the plant site, main equipment design, power supply system, thermodynamic system, combustion system, water supply system, control system, civil works, heating, ventilating, and air-conditioning (HVAC), pollution countermeasures, energy efficiency, water conservation and materials conservation measures, fire protection and safety, environmental impact assessment, social impact assessment, public consultation, financial analysis, and economic analysis. The feasibility study and EIA preparation are scheduled to be completed in the first quarter of 2011.

487. Bidding document preparation, preliminary design and detailed engineering design are also parts of the major project implementation activities during Stage 1. The bidding document preparation task may have different contents depending on whether PPP model will be adopted or not. Under the EPC option, bidding document should include technical specifications, bill of quantities, and engineering drawings in full compliance with the international practices and national bidding procedures. It will also include pre-bid conference, clarification during bidding, bid opening, bid evaluation, and bid awards. The bidding and engineering design tasks are scheduled to be undertaken during May 2011 to April 2013 for Phase I and June 2016 to April 2018 for Phase II.

488. The project preparation tasks under Phase I are scheduled to be completed by April 2013. The project preparation tasks under Phase II are scheduled to start in March 2016 and complete by April 2018.

B. Stage 2: Pre-construction Preparation

489. Under the project pre-construction tasks, several key project activities are to be undertaken, including power supply arrangement, communication facilities and initial civil works and site preparation. The pre-construction tasks are scheduled to be undertaken during February to April 2013 for Phase I and February to April 2018 for Phase II.
C. Stage 3: Procurement

490. The procurement activities include finalization of bidding documents, contract negotiation, and purchasing of equipment and delivery. Bidding document preparation and finalization tasks are scheduled to start in June 2011 and complete in September 2011 for Phase I. Bidding document preparation and finalization tasks are scheduled to start in May 2017 and complete in September 2017 for Phase II. Tendering, contract negotiation and contract award will be undertaken during October 2011 to March 2012 for Phase I. Tendering, contract negotiation and contract award and will be undertaken during February 2018 to July 2018 for Phase II. The procurement activities are scheduled to start in January 2012 and complete in May 2013 for Phase I. The procurement activities are scheduled to start in May 2017 and complete in July 2018 for Phase II.

D. Stage 4: Construction and Commissioning

491. The tasks at Stage 4 include construction of auxiliary facilities for HP system of CHP3 and Phase I; decommissioning of existing auxiliary facilities of CHP3; relocation of pipelines, grid, and associated facilities; civil works for main plant, coal yard and associated facilities; installation of major equipment and auxiliary facilities; and plant commissioning.

492. Construction of auxiliary facility for HP part and Phase I is scheduled to start in April 2013 and complete in November 2013. The decommissioning of existing auxiliary facilities of CHP3 is planned to start in July 2013 and complete in November 2013 for Phase I. The decommissioning of existing auxiliary facilities of CHP3 is planned to start in May 2017 and complete in December 2017 for Phase II. The relocation of pipelines, grid and associated facilities is planned to start in July 2013 and complete in November 2013 for Phase I. The relocation of pipelines, grid and associated facilities is planned to start in April 2017 and complete in October 2017 for Phase II. Civil works for main plant and coal yard is planned to start in June 2013 and complete in August 2015 for Phase I. Civil works for main plant and coal yard is planned to start in April 2018 and complete in September 2020 for Phase II. Civil works for preparing coal ash yard is scheduled during April – September 2014.

493. Installation of major and associated equipment is planned to start in March 2014 and complete in October 2015 for Phase I. Installation of major and associated equipment is planned to start in March 2019 and complete in October 2020 for Phase II. Commissioning for Phase I is planned to start in July 2015 and complete in December 2015. Commissioning for Phase II is planned to start in June 2020 and complete in November 2020.

494. The construction of Phase I of the Project is scheduled to start in April 2013 and complete in December 2015 while that for Phase II is scheduled to start in May 2017 and complete in November 2020.
Figure 13.1: Project Implementation Schedule

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Preparation Activities</td>
<td></td>
<td></td>
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<tr>
<td>Feasibility Study and EIA Preparation</td>
<td></td>
<td></td>
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<tr>
<td>Funding and Loan Effective Date</td>
<td></td>
<td></td>
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<tr>
<td>Bidding Document Preparation for EPC or BOT</td>
<td></td>
<td></td>
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<tr>
<td>Bidding Process</td>
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<tr>
<td>Bid Evaluation and Contract Award</td>
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<tr>
<td>Preliminary Design and Review</td>
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<tr>
<td>Detailed Engineering Design</td>
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<tr>
<td>Pre-Construction Activities</td>
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<tr>
<td>Power Supply Arrangement</td>
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<tr>
<td>Communication Facilities</td>
<td></td>
<td></td>
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<tr>
<td>Initial Civil Works and Site Preparation</td>
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<td></td>
</tr>
<tr>
<td>Procurement Activities</td>
<td></td>
<td></td>
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<tr>
<td>Finalization of Bidding Documents</td>
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<tr>
<td>Contract Awarding and Negotiation</td>
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<tr>
<td>Project Implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction of Auxiliary Facility for HP Part and Phase I</td>
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<td>✓</td>
</tr>
<tr>
<td>Decommissioning of existing auxiliary facilities of CHP3</td>
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</tr>
<tr>
<td>Relocation of Pipeline, Grid, and Associated Facility</td>
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<td>✓</td>
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<tr>
<td>Civil Work for Ash Yard</td>
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<td></td>
</tr>
<tr>
<td>Civil Work for Main Plant, Coal Yard, and others</td>
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<td>✓</td>
</tr>
<tr>
<td>Installation of main and auxiliary equipments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Commission</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: TA Team
XIV. CONCLUSIONS AND RECOMMENDATIONS

495. Based on meetings and discussions with ADB, MMRE, many government agencies and other stakeholders and reviewing available relevant documents, the TA Team has identified some issues that need to be addressed during the implementation of the Project following the completion this TA. Our recommendations are summarized in this section.

A. Project Financing

496. GoM has evaluated different ways to finance the CHP5 Project. However, as of the completion of this TA, GoM has not decided how to finance the Project. Thus, various project financing options were evaluated, including PPP model of financing, public sector financing and commercial financing. Due to the urgent need of increasing heat supply capacity in UB, it’s recommended that the GoM make a decision on financing the Project as soon as possible so associated subsequently actions can be taken to implement the Project.

B. Use of PPP

497. The CHP Project has been identified by the GoM as a project for implementation under a PPP model of financing. This is a new and innovative approach so far as Mongolia is concerned. This, in turn, could potentially add to implementation risk, and especially the risk of procurement delay. This is a very important consideration given the limitations of the current energy production system and the energy demand forecasts referred to earlier in this report. The study team's initial analysis suggests that PPP is a feasible approach and would avoid a heavy drain on the government's borrowing capacity. Whilst PPP procurement is likely to take longer than under a traditional financing route, international experience is that PPPs have faster construction performance that compensates for this. As identified in the financial analysis, PPPs have an inherently higher cost of finance than public procurement because PPP contractors would incur higher borrowing costs. Therefore, unless the PPP contractor can find compensatory cost savings then a PPP could create additional upward pressure on retail energy tariffs than if public financing is used.

498. We believe in the current circumstances of the CHP5 project that public financing of Phase I followed by use of PPP for phase II represents a lower risk procurement route, assuming funds can be made available without undue delay. However should PPP financing be decided upon or become necessary due to the unavailability of public funds, then we endorse the government preferred PPP model of using a generic BOO form of PPP contract - which in this case would effectively be a rehabilitate operate own (ROO) contract with a major upgrading included. In order to maximize of making the PPP a success we also feel Government should have a minority interest in the ROO arrangement as an equity contributor, and also shoulder some key non-commercial risks that could discourage PPP bidders or cause them to inflate their pricing. The existing CHP3 company should transition to become the CHP5 JV implementation vehicle with the PPP contractor having full management control.

C. Retirement Schedule of CHP2 and CHP3

499. The dates for the retirement for CHP2 and CHP3 have not been decided yet. The TA Team understands that there is proposal to convert CH2 to coal conversion plant where coal will be converted to smokeless coal. The Government decided that HP system of the CHP3 plant needs to be kept since some upgrades have been down in recent years. The retirement of these two plants will directly impact the load factor of the CHP5. Once the CHP5 plant is operational, it will be the most efficient plant in Mongolia so it makes sense to operate this
plant as much as possible. Thus, it’s recommended that the Government reassess whether to keep the HP system of CHP3 in operation once the Phase I is put into service.

D. Electricity and Heating Tariffs

500. Electricity and heating retail tariffs have increased by an annual average of 8.5% and 6.6% over the past decade broadly in line with inflation. Whilst this tariff has covered the cost of production of the existing generators to a large extent, it does not cover the cost of debt service. This has resulted in generating companies recording losses. There is also a large cross subsidy from electricity to heating. Plants are technologically obsolete and inefficient. The system is in urgent need of capacity expansion. The challenge lies in balancing the cost of investment in capacity and technology with affordability.

501. Under full concessionary financing where both Phase I and Phase II are undertaken the cost reflective electricity tariff on project completion is MNT 61/kWh and heating tariff MNT 19,467/Gcal. These are substantially higher than the CHP4 tariff of MNT 35.85/kWh and MNT 7,533/Gcal and the weighted average tariffs of CHP2, CHP3 and CHP4 of MNT 41.23/kWh and MNT 7,583/Gcal.

502. Presently there is a significant cross subsidy of heating by electricity. However, if Phase I only is undertaken the cost reflective tariffs are MNT 45/kWh and MNT16,590/Gcal. As the cost of finance rises so does the tariff, with PPP financing the electricity tariff increases to MNT 82/kWh (Phase I only MNT 48/kWh) and under all commercial financing it is MNT 94/kWh (Phase I only MNT 53/kWh). However in order for the project to be financially viable tariffs under PPP have to be further increased by 10% (Phase I and II) and by 7.5% on average for Phase I only.

E. Project Implementation Schedule

503. A project steering committee has been established to implement the Project and it’s chaired by the Vice Minister of MMRE with fourteen other members from various government agencies and other organizations. Due to the urgent need of heat in UB and short construction season in Mongolia, the project implementation schedule to complete Phase I by 2015 is very tight. The GoM needs to make a decision on how to finance Phase I of the Project and move forward to implementing the CHP5 project as soon as possible.

F. Feasibility Studies of Coal Mine Expansion

504. Coal will be supplied by the Baganuur and Shivee-Ovoo coal mines. However, both mines do not have enough spare capacities to meet the need to CHP5 plant. In order to ensure there is enough coal supply to CHP5 plant from these two mines, it is recommended that feasibility studies of expanding the mining operations and increasing production to the levels that will be needed by CHP5 plant. Additional overburdens will need to be removed in order to increase production and thus the feasibility studies should be performed as soon as possible.

G. Feasibility Study of Branch Railway

505. Due to significant increase in amount of coal to be transported through the branch railway from UB-1 Station to CHP3 coal yard, it has been identified that the branch railway needs to be enhanced to meet the need for CHP5. This branch railway also crosses a busy road and thus an overpass will be necessary. It’s recommended that a feasibility study be conducted on the expansion of this branch railway.
H. Study of UB District Heating Network

506. The UB district heating network is fairly large and getting more complex as the City has grown over the last decade. Energy losses are significant through the heating distribution network. UB Municipality also has a plan to expand the apartment development in many parts of the city. However, there are no specific and detailed plans to connect these new development areas to the UB district heating network. Detailed studies will be necessary to optimize the heating network so energy losses can be reduced and quality of heating services can be ensured. This study should be done concurrently with the implementation of the Phase I of CHP5 project.