ECONOMIC ANALYSIS

A. Introduction

1. The project will support improvement of the city's wastewater management, its central wastewater treatment plant (WWTP), sewer system, and pumping stations. The city's WWTP, and the sanitary sewer system and pumping stations, were built in 1965, and partially updated and expanded in 1987. They are in urgent need of structural rehabilitation and technological retrofitting. Breakdowns of the current system cause untreated water to discharge into the groundwater and the Kharaa River. Without the project, the existing WWTP would rapidly deteriorate and fail, as the remaining life of the facility has been estimated at just 2 years. Moreover, anticipated urban and industrial growth could not be served by wastewater management services. The project will directly benefit more than 45,000 residents (60.0% of the urban population) and indirectly, more than 76,400 residents. Once in operation, it is anticipated that an expanded sewer system will increase the beneficiary population to 62,000 residents (75.0%) by 2020. The project will also support institutional development, training, project management, and policy dialogue to ensure economic and financial sustainability.

2. The project economic analysis follows Asian Development Bank (ADB) guidelines and assesses the economic viability of the least-cost alternative using standard cost–benefit analysis.[1] The main viability parameters applied are the economic internal rate of return (EIRR) and economic net present value (ENPV). The project is economically feasible when the EIRR exceeds the economic opportunity cost of capital (EOCC) at 12%. The project is also tested for robustness under adverse economic conditions including cost overruns, decrease in benefits, and delay in implementation.

B. Project Economic Rationale, Goals, and Strategies

3. Government intervention for project financing is required to ensure that urban and industrial development in Darkhan is not hindered by deteriorating wastewater management facilities. The water and wastewater utility company, Darkhan Us Suvag (DUS), has experienced operational losses in 2009, 2010, 2012, and 2013. The main causes of losses are dilapidated facilities and networks, operational and management inefficiencies, and low, inappropriately set tariffs. Without external support, DUS cannot respond to the need for improved and expanded services which in turn will affect the economy. Users are willing to pay higher water and wastewater tariffs for the benefits of an improved system, and approval for tariff increases is pending.[2]

4. The project is designed to (i) increase the efficiency and effectiveness of the WWTP, (ii) enhance cost recovery through increased efficiency and expanded demand-based service delivery, (iii) ensure economic sustainability through cost-based and affordable tariffs, (iv) safeguard public health by reducing the incidence of water- and vector-borne diseases, and (v) stimulate economic activity. The project is considered high priority, timely, and well integrated with other investment activities in the city and the region (e.g., the Cities Development Initiatives for Asia). Improved efforts at cost recovery and operation and maintenance (O&M) positively impact the willingness to pay (WTP) of existing and potential customers.

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[1] ADB. 1999. *Handbook for the Economic Analysis of Water Supply Projects*. Manila; ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila.

[2] The tariff application submitted in 2013 and expected to be implemented in 2014 awaits approval by the National Water Services Regulatory Commission and the Competition and Consumer Rights Agency.

5. To ensure sustainability of the project and overall DUS operations, in addition to tariff increases, the Darkhan-Uul *aimag* (province) government needs to subsidize O&M costs arising from both water and wastewater operations in certain years. These subsidies have been assured by DAG to DUS. DAG will need to secure additional transfers from the national government's budget for infrastructure support (refer to Financial Analysis).[3]

C. Project Alternatives and Least-Cost Analysis

6. A range of technical alternatives has been developed, compared, and evaluated. Four options emerged as most technically and financially feasible, and most suitable for Darkhan: (i) option 1: rehabilitation of existing activated sludge plant with integrated fixed-film activated sludge technology; (ii) option 2: new step-feed activated sludge plant; (iii) option 3: new sequencing batch reactor plant; and (iv) option 4: hybrid, modified bioreactor, and activated sludge plant and integrated fixed-film activated sludge system.

7. Based on an engineering assessment, no clear best option was identified in terms of qualitative and quantitative advantages. All options potentially provide a level of wastewater treatment adequate to satisfy Mongolian wastewater discharge standards. The lifetime costs of the four options do not differ widely, and O&M costs only differ marginally. However, the reuse of structural elements of the existing plant will provide savings in capital cost.

8. In determining the least-cost alternative among the technical options, the average incremental economic cost (AIEC) approach is adopted. In the analysis, AIEC calculates the net present value of incremental investment and O&M costs against the net present value of incremental wastewater production (output) to arrive at the cost per cubic meter (MNT/m^3) of the project alternative. Costs and output are based on with- and without-project scenarios, and discounted using the economic discount rate at 12%. The least-cost alternative is option 1, the selected solution, with combined capital and operating costs (lifetime cost) at MNT36,985 million and the resulting AIEC at MNT4,366/m^3. Table 1 presents least-cost analysis results.

Table 1: Least-Cost Analysis of Technical Options[a]

Item	Unit	Option 1	Option 2	Option 3	Option 4
Capital and O&M costs	MNT million	36,985	47,165	44,650	44,037
Demand (production)	m^3	8.471	8.471	8.471	8.471
AIEC	MNT/m^3	4,366	5,567	5,271	5,198

AIEC = average incremental economic cost, m^3 = cubic meter, MNT/m^3 = cost (togrog) per cubic meter, O&M = operation and maintenance.

[a] Calculated in net present value.

Source: Asian Development Bank estimates.

D. Cost-Benefit Analysis

9. **Economic costs.** Project demand and cost are based on with- and without-project scenarios, assessed over a 25-year period. Economic costs are in constant December 2013 prices, converted from financial costs using the domestic price numeraire. The financial investment cost is converted into economic cost by excluding taxes and duties, as well as price contingencies, and using conversion factors where appropriate. The financial O&M cost of the proposed physical works, including staff salaries and other recurrent costs, are converted to economic costs by excluding effects of inflation, taxes and duties, and other transfer payments

[3] Financial Analysis (accessible from the list of linked documents in Appendix 2). Despite proposed triennial tariff increases, subsidies amounting to MNT572 million will be needed in 2016, MNT851 million in 2017, and MNT552 million in 2020. These are required to avoid compromising the tariff affordability of consumers during the period. After 2020, the tariffs are sufficient to recover all costs fully, including debt servicing and depreciation.

using shadow pricing. Capital and O&M costs are distributed into traded and non-traded components and skilled and unskilled labor. The shadow wage rate factor assumed in the analysis is 0.80 for unskilled labor and 1.00 for skilled labor, and 1.03 shadow exchange rate factor for traded goods. Unskilled labor comprises 30% of the total labor requirement.

10. **Economic benefits.** Project economic benefits arise from non-incremental and incremental wastewater generation, estimated at 80% of water consumption. Non-incremental wastewater consists of wastewater from the existing collection system. As the DUS implements programmed improvements and additions to the existing water supply system, supplies to existing consumers are augmented and excess volume made available to new consumers. These additional supplies comprise incremental water, later processed in the wastewater collection and treatment system to be collected as incremental wastewater.

11. DUS reports average domestic water consumption—comprising residential, institutional, and commercial entities—at 120 liters per capita per day (lpcd). Industrial consumption is 12 cubic meters per day (m^3/day) per establishment. Based on engineering estimates on the non-connected population, domestic consumption averages 80 lpcd. Wastewater generation is 80% of these volumes, which is assumed in the without-project situation. In establishing non-incremental and incremental wastewater, the with- and without-project scenarios are compared and analyzed. Table 2 presents the per capita wastewater projection for connected and non-connected users under with- and without-project scenarios.

Table 2: Incremental and Non-incremental Demand

Item	Unit	2012	2015	2020	2025	2030	2035
Without Project							
Connected Population	person	39,371	39,371	39,371	39,371	39,371	39,371
Domestic	lpcd	89	96	96	96	96	96
Industrial	m^3/day	9	9	9	9	9	9
Non-connected Population	person	11,207	14,631	18,690	22,502	26,175	29,348
Consumption per capita	lpcd	60	64	64	64	64	64
Industrial	m^3/day	9	9	9	9	9	9
With Project							
Connected Population	person	39,371	39,371	39,371	39,371	39,371	39,371
Domestic	lpcd	89	102	107	112	118	120
Industrial	m^3/day	9	9	9	9	9	9
New Consumers[a]	person		14,631	18,690	22,502	26,175	29,348
Domestic	lpcd	60	102	107	112	118	120
Industrial	m^3/day	9	9	9	9	9	9
Non-incremental							
Connected Population							
Domestic	lpcd	89	96	96	96	96	96
Industrial	m^3/day	9	9	9	9	9	9
Incremental							
Connected Population							
Domestic	lpcd	0	6	11	17	22	24
Industrial	m^3/day	0	0	0	0	0	0
New Consumers[a]							
Domestic	lpcd	60	102	107	112	118	120
Industrial	m^3/day	9	9	9	9	9	9

lpcd = liter per capita per day, m^3/day = cubic meter per day.
[a] From non-connected population.
Source: Asian Development Bank estimates based on data from Darkhan Us Suvag.

12. The analysis assumes that non-connected population within the service area will eventually connect to the system once improvements are in place. Wastewater from these new connections is treated as incremental volume. Non-incremental demand derives from the

existing connected population. Additional or incremental wastewater is generated from existing connections as a result of augmented supply, economic development, and improved well-being.

13. Economic benefits are estimated using the WTP approach. A survey was conducted in Darkhan to determine consumer WTP for expected project benefits, including savings from improved plumbing and services, reduced health and medical costs, improved environment, and savings from costs of mitigating overflow polluting the Kharaa River. The survey reveals that 80% of respondents are satisfied with current sewerage service, but they are largely unaware of the sanitation issues in Darkhan. The mean WTP price for wastewater treatment services is calculated at MNT1,076/m.[4]

14. The survey also explored the potential benefits of ecological improvements of the Kharaa River and wastewater reuse. Some 83% of residents are concerned about environmental degradation of the Kharaa River, and 64% support reuse of grey water, with 41% willing to reuse grey water to flush toilets. Some 68% indicated that they are willing to pay in addition an average of MNT15,100 for a new reticulated sewer connection that would allow bathing and other recreational activities in the river, plus an additional MNT10,000 for reuse of water for industries and households. The levels of WTP for potential benefits indicate likely project sustainability.

15. The value of non-incremental benefits is measured by multiplying the wastewater generated from the existing and improved systems by the economic supply price. The value of incremental benefits is obtained by multiplying incremental volume by the WTP or demand price. The supply price is based on real increases following the proposed tariff schedule given in the project financial analysis—increases of 30% (including subsidy) in 2015 and 15% in 2018, after which the price remains constant until 2040. For the WTP price, the required increases are 22% in 2015, 17% after 5 years in 2020, and 14% after 10 years in 2030, remaining constant thereafter. The present value of economic benefits is estimated at MNT38,159 million. With economic costs at MNT35,875, the benefit–cost ratio is calculated at 1.06, making the project economically feasible.

16. **Economic internal rate of return and sensitivity analysis.** The cost and benefit streams are established using the assumptions described above, discounted at the EOCC at 12.0%. The proposed project is economically viable, with the EIRR at 13.7%, exceeding the EOCC. The ENPV is calculated to be MNT1,977 million.

17. The resulting EIRR is tested for sensitivity to adverse economic conditions including (i) an increase in economic capital cost by 10%, (ii) an increase in economic O&M cost by 10%, (iii) a decrease in benefits by 10%, and (iv) a 1-year delay in project implementation. The results show that the project remains robust despite 10% cost overruns, but falls slightly below the EOCC with a decrease in benefits and a delay in implementation. Switching values measure the changes in costs and benefits under the same scenarios, with the EIRR set at 12% and ENPV at 0. The sensitivity indicators reflect the changes in EIRR and ENPV relative to the changes in the variables. A high value indicator represents high sensitivity to the variable. Table 3 presents the discounted cash flow analysis.

[4] The WTP value was estimated using maximum, mean, and median averages. The mean at MNT1,076/m^3 was used in the analysis. The question asked of sample households was, “Assume that the improvement of the WWTP of Darkhan *soum* (district) would require your household to pay the following amounts of additional tax per year (for 5 years), and that other households also pay their fair share: set 1 respondents: MNT10,000, set 2 respondents: MNT15,000, set 3 respondents: MNT20,000, set 4 respondents: MNT25,000, and set 5 respondents: MNT30,000.”

Table 3: Economic Internal Rate of Return and Sensitivity Analysis (MNT million)

	Benefits			Costs			Net Inflow (Outflow)					
Year	Total	Incremental Value	Non-incremental Value	Total	Capital	O&M	Base Case	Capital Cost+ 10%	O&M Cost +10%	Benefits –10%	Costs +10%, Benefits –10%	Delay by 1 year
2015	4,238	2,635	1,604	4,788	3,036	1,752	(549)	(853)	(724)	(973)	(1,452)	(4,788)
2016	4,317	2,713	1,605	12,537	10,728	1,809	(8,220)	(9,292)	(8,400)	(8,651)	(9,905)	(8,298)
2017	4,398	2,793	1,605	10,963	9,096	1,867	(6,565)	(7,475)	(6,752)	(7,005)	(8,101)	(6,646)
2018	4,561	2,874	1,687	8,650	6,723	1,928	(4,089)	(4,762)	(4,282)	(4,545)	(5,410)	(4,252)
2019	4,646	2,958	1,688	3,486	1,496	1,990	1,159	1,010	960	695	346	1,075
2020	5,235	3,546	1,689	2,052	0	2,052	3,183	3,183	2,978	2,660	2,454	2,594
2021	5,417	3,644	1,773	2,110	0	2,110	3,307	3,307	3,096	2,765	2,554	3,125
2022	5,516	3,744	1,772	2,169	0	2,169	3,347	3,347	3,130	2,795	2,578	3,247
2023	5,618	3,847	1,771	2,231	0	2,231	3,387	3,387	3,164	2,825	2,602	3,285
2024	5,810	3,951	1,859	2,294	0	2,294	3,516	3,516	3,287	2,935	2,706	3,324
2025	5,915	4,057	1,858	2,358	0	2,358	3,557	3,557	3,321	2,965	2,729	3,452
2026	6,024	4,165	1,858	2,431	0	2,431	3,593	3,593	3,350	2,991	2,748	3,485
2027	6,135	4,276	1,858	2,505	0	2,505	3,630	3,630	3,379	3,016	2,766	3,519
2028	6,248	4,389	1,858	2,582	0	2,582	3,666	3,666	3,408	3,041	2,783	3,553
2029	6,364	4,505	1,858	2,661	0	2,661	3,703	3,703	3,437	3,066	2,800	3,587
2030	7,147	5,288	1,859	2,740	0	2,740	4,407	4,407	4,133	3,692	3,418	3,624
2031	7,248	5,388	1,860	2,818	0	2,818	4,430	4,430	4,148	3,705	3,424	4,329
2032	7,351	5,490	1,861	2,898	0	2,898	4,453	4,453	4,163	3,718	3,428	4,350
2033	7,456	5,594	1,862	2,980	0	2,980	4,476	4,476	4,178	3,730	3,432	4,371
2034	7,562	5,699	1,863	3,064	0	3,064	4,498	4,498	4,191	3,741	3,435	4,391
2035	7,663	5,800	1,864	3,148	0	3,148	4,516	4,516	4,201	3,749	3,435	4,415
2036	7,747	5,884	1,864	3,230	0	3,230	4,517	4,517	4,194	3,742	3,419	4,433
2037	7,833	5,969	1,864	3,316	0	3,316	4,517	4,517	4,186	3,734	3,403	4,432
2038	7,920	6,056	1,864	3,403	0	3,403	4,517	4,517	4,177	3,725	3,385	4,430
2039	8,008	6,144	1,864	3,492	0	3,492	4,515	4,515	4,166	3,715	3,365	4,427
2040	8,097	6,234	1,864	3,584	0	3,584	4,513	4,513	4,154	3,703	3,345	4,423
EIRR							13.7%	12.0%	12.4%	10.5%	7.9%	10.3%
ENPV	37,843	25,637	12,205	35,866	20,409	15,457	1,977	(64)	431	(1,808)	(6,041)	(2,417)
Sensitivity Indicator												
EIRR								10.29	7.84	19.01	34.44	38.27
ENPV								10.32	7.82	19.14	40.56	42.55
Switching Value												
EIRR								0.10	0.13	0.05	0.03	0.14
ENPV								0.10	0.13	0.05	0.02	0.02

( ) = negative, EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operation and maintenance.
Source: Asian Development Bank estimates.