ECONOMIC ANALYSIS

1. The project will develop a low-carbon district heating system in the eastern part of Hohhot City in Inner Mongolia Autonomous Region (IMAR), the People's Republic of China (PRC). The system will cover 29.7 million square meters (m^2) of heating areas that are currently connected to small, inefficient neighborhood coal-fired boilers (6.7 million m^2) or are using household stoves (23.0 million m^2) without emission control.

2. District heating is considered to be an energy-efficient heating method for densely populated urban areas, and has the added advantage of better emission control from fossil fuel combustion. In the PRC, coal has been the dominant fuel source for district heating because of its abundance and price advantage. However, it creates significant impacts on the environment and human health. Similar to other large cities in the PRC, Hohhot City experiences hazy skies and high concentrations of inhalable particulate matter during wintertime. Responding to growing concerns about urban air pollution, the State Council of the PRC promulgated the Air Pollution Prevention Act and specified targets to reduce air pollutant emissions.[1] Aligned with this policy and target, Hohhot Municipal Government issued a policy to promote natural gas district heating by providing (i) a natural gas subsidy for residential district heating, and (ii) financial support to heating operators who replace small coal-fired neighborhood boilers with natural gas boilers in central business districts.

3. In March 2013, the Government of the PRC issued a policy note to promote the use of wind energy in district heating schemes where a high level of excess wind capacity exists. IMAR has the largest wind resources in the PRC, with an estimated potential wind generation capacity of 380 gigawatts using current technologies. In 2013, excess wind energy capacity reached 11.3 terawatt hours, sufficient to provide heating for up to 100 million m^2. Considering the benefits of using excess wind energy for district heating, the Government of IMAR is promoting wind-to-heat projects as a means of reducing wind curtailment.[2] Several pilot wind-to-heat projects are either under construction or in operation.[3]

4. In line with government policies on the use of cleaner fuel for district heating and emission reduction targets (para. 2), the project will develop a natural gas-based heating system covering 28.7 million m^2 of heating zones, and will pilot the use of excess wind power in district heating to cover 1.0 million m^2—3% of the total project heating areas. For the economic analysis of the project, coal-based district heating using heat-only boilers is considered as a business-as-usual scenario to meet space heating demand up to 2020 under the assumption that without the project intervention, a coal-based district heating system would be introduced to meet growing demand for heat.

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[1] The State Council of the PRC promulgated the Air Pollution Prevention Act in September 2013. In January 2014, the Government of the PRC set targets for provinces to reduce air pollution by 5%–25%. Under these targets, IMAR will have to reduce the emission of particles smaller than 2.5 micrometers by 10% annually by 2017.

[2] Wind curtailment occurs when wind is available but the grid operator does not permit power to be sent to the grid.

[3] In IMAR, Tongliau County is constructing a pilot wind district heating project with a heating coverage of 450,000 m^2 using low-voltage 2.16 megawatt (MW) boilers, Zhongqi County operates a 17 MW wind-to-heat project using low-voltage 2.16 MW boilers with a heating coverage of 115,000 m^2, Li Xi town in Chifeng City is constructing a 20 MW wind-to-heat project using high-voltage 10 MW boilers, and Siziwang County is also constructing a 52 MW wind-to-heat project using low-voltage 2.16 MW boilers with 500,000 m^2 of heating area coverage. The project is unique in that it will use two high-voltage larger-scale (25 MW) electrode boilers, which are the most suitable and economical for urban district heating system.

5. **Economic costs.** The economic analysis of the project was conducted in accordance with the Asian Development Bank (ADB) *Guidelines for the Economic Analysis of Projects*.[4] It was conducted for the project lifespan of 25 years with a project implementation period of 5 years. The residual value at the end of the project life is assumed to be zero. All prices and costs are expressed in 2013 constant prices, using the world price numeraire. The analysis was carried out using the standard conversion factor of 0.987 for shadow pricing of non-tradable goods and services, and a shadow wage rate factor 0.67 for unskilled labor.[5]

6. The financial costs were converted to economic values excluding taxes, subsidies, and price contingencies, then the conversion factors were applied. The capital costs of the project include costs related to civil works, equipment and materials, and consulting services. These occur during the construction period, which is within the first 5 years of the project. The operation and maintenance (O&M) costs, assumed to remain constant in real terms, comprise the costs of natural gas (fuel inputs), wind power purchase, salaries, overhead, utilities including water and electricity, and administration expenses. O&M costs also include a subsidy on natural gas (CNY0.8 per normal cubic meters) and wind power (CNY0.33 per kilowatt hour). The O&M costs occur throughout the 30-year lifespan of the project.

7. **Economic benefits.** The economic benefits of the project include (i) revenues from the space-heating services—calculated as the heating area multiplied by end user's willingness to pay (CNY per m^2)—as incremental benefits; (ii) coal use saving (665,150 tons annually) from replacing the coal-based heating with natural gas and wind-powered heat boilers as a non-incremental benefit; and (iii) environmental benefits, which are reflected in the net reduction of environmental costs associated with heat source conversion from coal to natural gas and wind power.[6] The environmental benefits are estimated using the avoided annual net emissions associated with heat source conversion in the heating areas that are currently connected to small, inefficient neighborhood boilers and household stoves. These are 842,307 tons of carbon dioxide, 6,904 tons of nitrogen oxides, 9,228 tons of sulfur dioxide, 65,455 tons of total suspended particulates, and 104,635 tons of coal ash multiplied by the unit environmental cost.[7] Additional health benefits of the project are not included in the analysis because there is no agreed methodology. However, they would be substantial, and would improve the project's economic internal rate of return (EIRR) under all scenarios, including sensitivity cases.

8. **Economic internal rate of return calculation.** The results of the EIRR and the economic net present value (ENPV) for the project are in Table 1. The EIRR with environment benefits for the project is 18.52%. All EIRRs (base case) are greater than 12% of the economic opportunity cost of capital. The ENPV for the project is CNY722.59 million.

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[4] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila.

[5] These conversion factors have been used consistently for recently approved energy projects in neighboring provinces in the PRC, such as the Shanxi Energy Efficiency and Environment Improvement Project (ADB. 2012. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Shanxi Energy Efficiency and Environment Improvement Project*. Manila).

[6] During project preparatory technical assistance, a willingness-to-pay survey was conducted in heat coverage areas of the project. Willingness to pay is about CNY7.2 per m^2 per month, which is comparable to the results of the willingness-to-pay survey for the Mongolia Autonomous Region Environment Improvement Project (Phase 2), the Shanxi Energy Efficiency and Environment Improvement Project, and the Heilongjiang Energy Efficient District Heating Project.

[7] Average emission charges during 2009-2013 are used for sulfur dioxide, nitrogen oxides, and particulate matter. The construction material market price during 2009-2013 is used for ash. The environment benefits of carbon dioxide emission reduction are estimated using the marginal abatement cost as a proxy for the economic benefits of emission reduction. The carbon dioxide price (CNY19.0 per ton) in the PRC is based on the prevailing market price for Chinese Certified Emission Reduction credits, which are traded in the domestic carbon market.

Table 1: Economic Analysis of the Project
(CNY million)

Year	Capital Cost	O&M Cost	Economic Benefit: Incremental	Economic Benefit: Non-Incremental	Economic Benefit: Net Environmental Benefit	Net Benefit
2015	63.53	0.00	0.00	0.00	0.00	(63.53)
2016	277.21	0.00	0.00	0.00	0.00	(277.21)
2017	581.37	0.00	0.00	0.00	0.00	(581.37)
2018	548.64	0.00	0.00	0.00	0.00	(548.64)
2019	388.86	685.32	779.18	156.7	3.07	(135.23)
2020	65.45	1,142.20	1,298.64	261.17	5.11	357.27
2021		1,142.20	1,298.64	261.17	5.11	422.72
2022		1,142.20	1,298.64	261.17	5.11	422.72
2023		1,142.20	1,298.64	261.17	5.11	422.72
2024		1,142.20	1,298.64	261.17	5.11	422.72
2025		1,142.20	1,298.64	261.17	5.11	422.72
2026		1,142.20	1,298.64	261.17	5.11	422.72
2027		1,142.20	1,298.64	261.17	5.11	422.72
2028		1,142.20	1,298.64	261.17	5.11	422.72
2029		1,142.20	1,298.64	261.17	5.11	422.72
2030		1,142.20	1,298.64	261.17	5.11	422.72
2031		1,142.20	1,298.64	261.17	5.11	422.72
2032		1,142.20	1,298.64	261.17	5.11	422.72
2033		1,142.20	1,298.64	261.17	5.11	422.72
2034		1,142.20	1,298.64	261.17	5.11	422.72
2035		1,142.20	1,298.64	261.17	5.11	422.72
2036		1,142.20	1,298.64	261.17	5.11	422.72
2037		1,142.20	1,298.64	261.17	5.11	422.72
2038		1,142.20	1,298.64	261.17	5.11	422.72
2039		1,142.20	1,298.64	261.17	5.11	422.72
2040		1,142.20	1,298.64	261.17	5.11	422.72
2041		1,142.20	1,298.64	261.17	5.11	422.72
2042		1,142.20	1,298.64	261.17	5.11	422.72
2043		1,142.20	1,298.64	261.17	5.11	422.72
2044		1,085.09	1,024.62	221.54	4.03	165.11
		ENPV			CNY722.59 million	
		EIRR			18.52%	

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

9. **Sensitivity analysis.** Sensitivity analysis was conducted to assess the sensitivity of the EIRR to economic projections (Table 2). Under this analysis, the project is sensitive to changes in benefits but remains robust under all scenarios.

Table 2: Sensitivity Analysis for Economic Internal Rate of Return

	Base	Case 1: Benefits Decrease by 10%	Case 2: Capital Costs Increase by 10%	Case 3: O&M Costs Increase by 10%	Case 4: 1 Year Implementation Delay
EIRRs	18.52%	11.72%	17.00%	13.70%	18.49%

EIRR = Economic Internal Rate of Return, O&M = operation and maintenance.
Source: Asian Development Bank estimates.