CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

<table>
<thead>
<tr>
<th>Project Title:</th>
<th>PRC: Air Quality Improvement in the Greater Beijing–Tianjin–Hebei—Shandong Clean Heating and Cooling Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost ($ million):</td>
<td>711.51 million</td>
</tr>
<tr>
<td>Location:</td>
<td>Jinan City, Shandong Province</td>
</tr>
<tr>
<td>Sector:</td>
<td>Energy</td>
</tr>
<tr>
<td>Theme:</td>
<td>Clean heating and cooling</td>
</tr>
<tr>
<td>Brief Description:</td>
<td>Various aspects of this Project could be impacted by changes in climate. First and foremost, the climate risk assessment points to medium to high risk in terms of changes in extreme rainfall and temperatures at the Project sites. This can pose various demands on the Project. First, is the design of the core infrastructure. As temperature increases, the demand for cooling could increase remarkably. Hence, the design of the cooling technology, related pumps, pipes and power supplies for energy distribution should consider these risks and either incorporate design principles upfront from those aspects of infrastructure design that are difficult to change after construction (such as pipe size or wall thickness) to manage the changes in energy demanded over time versus those aspects that are more readily adapted such as cooling technologies and pumping systems needed to handle potential changes in energy generation and distribution over time. Whether the system is used for heating or cooling, vital aspects of the above ground infrastructure will be exposed to extreme rainfall/snowfall and heat events. Such events pose risks to electrical systems and pumps if they are not situated at elevations that reduce their risk from inundation damage from extreme and prolonged climate events.</td>
</tr>
</tbody>
</table>

Source: Asian Development Bank estimates

II. SUMMARY OF CLIMATE CHANGE FINANCE

<table>
<thead>
<tr>
<th>Project Financing</th>
<th>Climate Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>Amount ($ million)</td>
</tr>
<tr>
<td>Asian Development Bank</td>
<td>399.91</td>
</tr>
<tr>
<td>Ordinary capital resources (regular loan)</td>
<td>399.91</td>
</tr>
<tr>
<td>Cofinancing*</td>
<td>0.75</td>
</tr>
</tbody>
</table>

* TA Grant from the Clean Energy Fund under the Clean Energy Financing Partnership Facility for supporting the project implementation. Source: Asian Development Bank estimates

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

A. Sensitivity of Project Component(s) to Climate or Weather Conditions and the Sea Level
1. Changes in monthly temperature and precipitation caused by seasonality and variability and local natural environment change can impact the whole life span and operation of the Project.
2. Intensified extreme rainfall could cause flooding or water logging in the project locations, and infrastructure damage and disruption to service.
3. Increased extreme high and cold temperature could cause operational risks, energy system overload and workplace safety risk.
4. Increased drought probability and frequency could cause water resources and food supply decrease.
5. Frost and snow extremes could cause infrastructure damage and operational disruptions.
### B. Climate Risk Screening

1. Seasonal and annual temperature could increase more rapidly than global mean temperature, and annual mean precipitation is projected to increase over time. This could pose risks for the whole lifespan of the Project.

2. Extreme precipitation could increase more rapidly than mean precipitation which is the most noticeable changed parameter and could have potentially very significant impacts on the subprojects as this could increase the risk of flooding and water logging, which could damage and/or disrupt above ground and underground heating and cooling infrastructure and thus disrupting the critical supply of heating and cooling services.

3. Extreme daily maximum temperature for all the subproject locations was projected to increase more rapidly than mean temperature change. This could cause operational risks, energy system overload and workplace safety risk and potential risk to residents if cooling systems fail to meet demands under such changed conditions.

4. Potential for an increase in extreme wind speed, even though mean wind speeds may decrease from the historical recorded speeds. Extreme wind speed increase could cause the damage of aboveground component of the Project, including the power lines and other components located in exposed locations.

5. Heating degree days will decrease as temperatures increase significantly with time, while cooling degree days could double with as air temperatures increase. This could cause the system overload or disruption during summer energy use peak time.

**Climate Risk Classification:** *high*

Please see the detailed risk assessment report in the Climate Change Assessment Report (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President).

### C. Climate Risk and Adaptation Assessment

(i) The expert assessed the climate change risks and vulnerability of the proposed Air Quality Improvement in the Greater Beijing—Tianjin—Hebei—Shandong Clean Heating and Cooling Project and provides in this report recommendations on managing the climate risks during design, construction and operation of the project. Three sub-projects are included in this report.

(ii) Primary climate risk and data analysis methodologies were identified and applied for first level climate change risks for the three subproject locations. Historical daily meteorological observation and gridded data were obtained from the Chinese Meteorological Administration database. This data was used to create the official baseline dataset for the project. Climate change scenario data was obtained from the SimCLIM data library and is based on up to 40 CMIP5 GCMs and 6 CORDEX RCMs. The climatic variables assessed are:

- Monthly precipitation and temperature (maximum, mean and minimum) changes
- Daily to subdaily extreme precipitation changes
- Extreme maximum temperature changes
- Drought duration and frequency change
- Extreme wind speed and changes
- Heating degree days and cooling degree days

(iii) Climate projections for 2050 and 2100 for RCP2.6, RCP4.5 and RCP8.5 are examined while applying GCM/RCM ensemble median changes.

(iv) The climate of all the subproject sites are in a similar temperate monsoon climate zone on the Jiaozhou peninsula of China. The seasonality of temperature and precipitation is clear and could shift slowly with climate change. Seasonal and annual temperature could increase more rapidly than global mean temperature, and annual mean precipitation is projected to increase over time.

(v) Extreme precipitation could increase more rapidly than mean precipitation which is the most noticeable changed parameter and could have potentially very significant impacts on the subprojects. Depth-Duration-Frequency (DDF) of extreme precipitation was analyzed for each subproject location based on the closest historical time series weather observation station. Selected extreme precipitation values are listed, including 5, 50- and 100-year return intervals (ARI). For validation the storm rain formulas for the closest city were collected and described.

(vi) Extreme daily maximum temperature for all the subproject locations was projected to increase more rapidly than mean temperature change. Extreme temperatures for different ARIs, from 2 to 300 years...
Drought probability was assessed for different severity and duration analysis using the Standard Precipitation Evapotranspiration Index (SPEI) method. The results indicate that even with a projected increase in annual precipitation, increasing temperatures could intensify evapotranspiration, thus the probability of drought severity and duration could increase under all the selected RCP scenarios.

Historical and future extreme daily maximum wind speed was analyzed using GEV methods. The 75th percentile of 22 GCM extreme wind speed change factors were applied to generate future scenarios. The results indicate the potential for an increase in extreme wind speed, even though mean wind speeds may decrease from the historical recorded speeds.

Historical and future scenarios of heating degree days and cooling degree days were calculated using a base temperature of 18°C. Heating degree days will decrease as temperatures increase significantly with time, while cooling degree days could double with an increase in air temperatures.

A cost benefit analysis was carried out based on ADB guidelines. Four adaptation options were identified, three benefit sensitivity levels were defined based on the extreme event change data generated for this report. The net present value (NPV) were analyzed for 20, 40, and 60 year project lifetimes, and three climate scenarios. Under the RCP2.6 scenario, with a lower benefit sensitivity level, NPV showed negative values in all three project lifetimes. Under the RCP8.5 scenario, with a high benefit sensitivity level, all NPV were positive. For different adaptation options, low cost options showed positive NPVs, while high cost adaptation options would generate negative NPVs under RCP8.5 scenario. With longer project lifetimes the NPVs increased correspondingly.

Other climate change risks which could not be analyzed in detail in the report: frost and snow, fire, and tornado are listed. The risks posed by these variables acknowledged in the climate change adaptation process.

Uncertainties and caveats exist in the climate risk assessment (CRA) process, from scenarios, General Circulation Model/Regional Climate Models (GCM/RCM) data, and observational data to methodologies of analysis. However, the climate change facts and physical laws support the overall results of an increasing trend in the frequency and magnitude of extreme events.

Given the nature of the proposed subprojects, both physical climate change risks at site and company business risks were taken into consideration in a systematic manner. Physical climate change risk could be managed at a project level as this can take on a more comprehensive, complete life cycle approach from initial planning to shut down.

Climate change adaptation measures should align with disaster risk reduction and environmental management planning. Compliance to climate change risk-related regulations and agreements need to be considered systematically.

Detailed climate change risk adaptation options and recommendations for the selected climate variables are listed for each subproject location. Other potential risks which could not be included for detailed analysis are also listed for consideration, including, frost and snow, fire, hail for specific risk locations.

D. Climate Risk Screening Tool and/or Procedure Used

Customized tools developed by ADB consultant based on the Intergovernmental Panel on Climate Change and ADB guidance.

IV. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

<table>
<thead>
<tr>
<th>Adaptation Activity</th>
<th>Target Climate Risk</th>
<th>Estimated Adaptation Costs ($ million)</th>
<th>Adaptation Finance Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase design standard of storm water and energy supply system</td>
<td>Extreme precipitation temperature and heatwaves</td>
<td>35.0</td>
<td>Better design of the complex systems of the Project could increase the climate change resilience. NPVs are positive in high climate change scenarios.</td>
</tr>
<tr>
<td>Adaptation Activity</td>
<td>Target Climate Risk</td>
<td>Estimated Adaptation Costs ($ million)</td>
<td>Adaptation Finance Justification</td>
</tr>
<tr>
<td>---------------------</td>
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</tr>
<tr>
<td>Apply better building material including: pipeline network, construction materials</td>
<td>Increasing extreme precipitation intensity and heat event</td>
<td>70.0</td>
<td>Better hardware and construction materials could increase resiliency and reduce maintenance costs. NPVs are positive in high climate change scenarios.</td>
</tr>
<tr>
<td>New Technology with better function and efficiency Redundant systems as this is a lifeline service (provision of heating and cooling)</td>
<td>Increased flood, heatwaves, drought and wind risks</td>
<td>110.0</td>
<td>Use advanced technology, better products could increase the efficiency reduce carbon emission and risks. Redundant system could reduce the risk of disruption of service. NPVs are positive in high climate change scenarios.</td>
</tr>
<tr>
<td>Include all above three activities</td>
<td>Integrated adaptation measures</td>
<td>140.0</td>
<td>Apply, better design standard, better material and construction and new technologies could produce a climate-proofed project. NPVs are positive in high climate change scenarios.</td>
</tr>
</tbody>
</table>

NPV = net present values
Source: Asian Development Bank estimates.

V. CLIMATE MITIGATION PLANS WITHIN THE PROJECT

<table>
<thead>
<tr>
<th>Mitigation Activity</th>
<th>Estimated Emissions Reduction (tCO₂e/year)</th>
<th>Estimated Mitigation Costs ($ million)</th>
<th>Mitigation Finance Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency improvement and energy conservation</td>
<td>3,429,000</td>
<td>280</td>
<td>Project component is considered a mitigation project per Subcategory 1.3 of the Mitigation Typology and per the list of eligible mitigation activities under the Guidance Note on Counting Climate Finance in Energy. Waste heat recovery, building energy efficiency improvement and energy efficient equipment costs are considered mitigation finance.</td>
</tr>
</tbody>
</table>
| Renewable energy - biomass | 169,000 | 40 | Project component using biomass to generate electricity and provide heating that will replace inefficient coal fired boilers for power generation and heating qualify as a mitigation component following Subcategory 3.1 of the Mitigation Typology and per list of eligible mitigation activities under the Guidance Note on Counting Climate Finance in Energy. The
<table>
<thead>
<tr>
<th>Mitigation Activity</th>
<th>Estimated Emissions Reduction (tCO₂e/year)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Estimated Mitigation Costs ($ million)</th>
<th>Mitigation Finance Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy - geothermal</td>
<td>392,000</td>
<td>40</td>
<td>Project component using deep-well geothermal energy to provide heating that will replace inefficient coal fired boilers and household stoves for heating qualify as a mitigation component following Subcategory 3.1 of the Mitigation Typology and per list of eligible mitigation activities under the Guidance Note on Counting Climate Finance in Energy. The whole geothermal component cost is considered mitigation finance.</td>
</tr>
</tbody>
</table>

<sup>a</sup> tCO₂e = tons of carbon dioxide equivalent.

<sup>b</sup> Energy savings/year x emission factor = GHG emissions reduction.

<sup>b</sup> ADB (Sustainable Development and Climate Change Department; Strategy and Policy Department). 2017. Guidance Note on Counting Climate Finance in Energy. Memorandum. 5 January (internal).

Source: Asian Development Bank estimates.