SECTOR ASSESSMENT (SUMMARY): ENERGY

Sector Road Map

1. Sector Performance, Problems, and Opportunities

1. The greater Beijing–Tianjin–Hebei (BTH) region spans more than 20% of the total landmass of the People's Republic of China (PRC) and is home to nearly 30% of the country's population.[1] However, it is one of the most polluted regions in the PRC and in 2015 accounted for 42.0% of national carbon dioxide emissions, 39.6% of sulfur dioxide, and 39.5% of nitrogen oxides.[2] The region's rich endowment of energy and mineral reserves, availability of excellent land and sea transport infrastructure, and proximity to major consumption centers have led to rapid industrialization with a high concentration of highly polluting and energy-intensive industries. High concentrations of major air pollutants, such as sulfur dioxide, nitrogen oxide, ozone, and inhalable particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$), significantly impact public health and impede the region's sustainable growth. Shandong Province, as one of the most important regional economies in greater BTH region, suffers serious air pollution. In 2015, the average annual $PM_{2.5}$ level reached 66.4 micrograms per cubic meter ($\mu g/m^3$) in Shandong Province (among the top five highest), and 90.3 $\mu g/m^3$ in Jinan city, its capital, significantly exceeding regulated standards in the PRC and most developed countries.[3] Coal combustion is the largest contributor of $PM_{2.5}$ in Jinan city during the winter heating season.[4] Reducing and/or replacing coal consumption by switching fuels and/or reducing demand is identified as the most effective intervention.[5]

2. **Deep-well geothermal for heating subsector overview.** As a pollution-free clean source, geothermal energy offers an environment-friendly alternative to the current practice of using coal-based space heating. According to the China Geological Survey census in 2015, hydrothermal resources in the PRC amount to 1.25 trillion tons of standard coal equivalent (tce) and hot-dry-rock geothermal resources amount to 856 tce, with a total annual geothermal exploitation potential of about 2.6 billion tce.[6] Shandong Province alone has a total hydrothermal exploitation potential for heating and cooling of about 17.4 billion tce.[7] However, the annual usage of geothermal resources in the PRC was only 21 million tce in 2015, while in Shandong Province it was only about 1.6 million tce (footnote 6). By the end of 2015, Shandong Province used hydrothermal resources to heat and cool an area of 27 million square meters (m^2). By 2030 it targets achieving 300 million m^2 (footnote 6). Although many of the core technologies and much of the equipment involved in deep-well geothermal heating are well developed, heating from deep-well geothermal energy is not widely deployed due to the lack of a good understanding of drilling, geological conditions, and special equipment. This confines participants in the deep-well geothermal heating industry to a limited number of qualified enterprises.

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[1] The greater Beijing–Tianjin–Hebei region refers to Beijing and Tianjin municipalities; Hebei, Henan, Liaoning, Shandong, and Shanxi provinces; and Inner Mongolia Autonomous Region.
[2] National Bureau of Statistics. 2016. *Statistical Yearbooks.* Beijing.
[3] The air quality standard for $PM_{2.5}$ in the PRC (GB 3095-2012) is 35 $\mu g/m^3$. Japan and the United States have set a standard of 15 $\mu g/m^3$, while the World Health Organization standard is 10 $\mu g/m^3$.
[4] Jinan Environmental Protection Bureau. *Source of PM_{10} and $PM_{2.5}$ in Jinan in 2017*. Jinan.
[5] Asian Development Bank (ADB). 2017. *Technical Assistance to the People's Republic of China for Developing Cost-Effective Policies and Investments to Achieve Climate and Air Quality Goals in the Beijing–Tianjin–Hebei Region.* Manila.
[6] China Geological Survey. 2016. *China Geothermal Resource Census Report*. Beijing.
[7] Shandong Development and Reform Commission. 2017. *Provincial Mid-and-Long-Term Planning for New Energy and Renewable Energy Development (2016–2030)*. Jinan.

3. **Key issue in the geothermal-for-heating subsector.** Large upfront costs, lack of technical understanding and operational experience, and uncertain future revenues are hurdles to engaging sufficient participants—both state-owned and private—in the deep-well geothermal-for-heating industry. There is a strong need for financial and nonfinancial incentives to bridge the investment gap. Financial support, knowledge and operational capacity building, concessional agreements, and other aspects that can secure future revenue generation from heat supply are necessary to incentivize more participants to join the market and consequently achieve economies of scale.

4. **Rural heating subsector overview.** Heating demand in rural areas of the PRC is primarily met by coal and unprocessed biomass such as straw and firewood. The energy efficiency of buildings in rural area remains low because (i) most residential buildings are single-story brick houses, which have a large surface-area-to-volume ratio compared with more compact urban buildings; (ii) air leaks around windows and doors; and (iii) buildings are not properly oriented. Of these factors, thermal leakage due to permeable windows and doors accounts for 40%–50% of total building energy loss.[8] In 2015, building energy consumption in the PRC reached 857 million tce (20% of total energy consumption), of which the rural share was 197 million tce.[9] By the end of 2015, only 20% of rural buildings had undertaken energy improvement measures.[10] Improving building energy efficiency in Shandong Province could save about 31.1 million tce by 2020, with most of these savings coming from rural areas.[11]

5. **Key issue in the rural heating subsector.** Although the PRC has launched national and regional plans to improve building efficiency, there is still a strong need in rural areas to promote clean heating and building energy efficiency improvements because of (i) their relatively high upfront costs compared to the current practice of non-clean heating, (ii) lack of awareness of the health benefits from clean heating, and (iii) the lack of appropriate business models.

6. **District cooling subsector overview.** Air conditioning in urban areas takes more than 40% of the total power supply during peak periods in the PRC.[12] Compared to independent air conditioning systems, district cooling has the following advantages: (i) the total installed capacity of refrigeration units can be reduced by about 40%–50%, leading to more efficient use of space and less investment for cooling installations, pumps, and electric transmission and distribution; (ii) the overall efficiency of equipment can be improved while the operation and management cost can be reduced by 10%–15% by using a smaller but more skilled team and a more advanced commissioning system;[13] (iii) peak demand can be shifted and optimized by reducing peak load consumption and using ice storage; and (iv) district cooling can be supplied through existing district heating pipelines, increasing the efficiency of pipeline investment.

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[8] Y. Wu and C. Liu. 2007. *Research on Economic Incentives and Policies to Promote Construction Energy Saving in China.* Beijing: China Architecture & Building Press.

[9] China Association of Building Energy Efficiency. 2017. *China Building Energy Consumption Research*. Shanghai.

[10] Government of the People's Republic of China, Ministry of Energy. 2017. *Plan for Clean Heating in Northern PRC (2017–2021).* Beijing.

[11] Shandong Provincial Government, Housing and Urban–Rural Development Department. 2016. *13th Five-Year-Plan of Shandong Green Building and Building Energy Saving (2016–2020)*. Jinan.

[12] Government of the People's Republic of China, National Development and Reform Commission. 2012. *National Implementation Guidance for Promotion of Key Energy Efficient Technology*. Beijing.

[13] China Building Industry Press. 2015. *Design Standards for Energy Efficiency of Public Buildings (GB50189-2015).* Beijing. The mandatory provision for the energy efficiency of a small- or mid-scale water chilling unit is a coefficient of performance of 4.1–4.5. The coefficient of performance of a district cooling water chilling unit is usually higher than 5.5.

7. Building cooling demand in the PRC is expected to double by 2030. District cooling networks can meet some of this rapidly growing demand, taking advantage of synergies across local energy systems.[14] Those synergies normally include the use of off-peak cooling generation (e.g., the use of variable renewable energy sources with ice storage) and other locally available resources (e.g., natural cooling from rivers or excess heat from adsorption chillers).[15]

8. **Key issue in the district cooling subsector.** Although district cooling has many advantages over individual cooling systems, an inadequate cooling load, low cooling tariffs, and a low utilization factor leads to low-profit business performance and disincentivizes participation across the industry.

9. **Biomass subsector overview.** By 2015, utilization of biomass for energy amounted to about 35 million tce, or only 7.6% of the total available amount.[16] Shandong Province is the largest agricultural province in the PRC, producing about 10% of the country's biomass stalk. Most of the uncollected agricultural waste is burned in the field, a practice that has been identified as one of the culprits for smog in most cities in the PRC. Using biomass as an alternative energy source is an effective and economic way to mitigate climate change and combat air pollution. Furthermore, biomass for combined heat and power has a strong cost competitiveness over coal where the cost of biomass for combined heat and power is CNY40–CNY60 per gigajoule and that for a coal-fired boiler is CNY48–CNY69 per gigajoule.[17]

10. **Key issue in the biomass subsector.** The lack of a standardized market means the price and quality of biomass feedstocks can change quickly. Farmers or collection agencies can raise the price when the supply is limited, imposing additional operating costs. Variations in moisture content, the presence of impurities, and uncertain calorific value lead to unstable performance, adding to maintenance costs and requiring sophisticated management.

2. Government's Sector Strategy

11. The Government of the PRC is committed to scaling up its efforts to control air pollution. It upgraded the national air quality standards in 2009 and 2012 to levels equivalent to those in most developed countries. The Environmental Protection Law, promulgated in 1989 and revised in 2014, imposed greater responsibilities on enterprises and local authorities to mitigate and monitor air pollution. In 2013, the State Council issued the Comprehensive Action Plan on Prevention and Control of Air Pollution, 2013–2017. In response, the government set goals to reduce pollution emissions. The PRC's Thirteenth Five-Year Plan for Geothermal Energy Exploration and Utilization targets the annual use of 40 million tce of geothermal energy for heating by 2020, of which half will be deployed in the core BTH area. The Biomass Energy Development Plan under the Thirteenth Five-Year Plan (2016–2020) targets the annual use of 30 million tons of biomass briquette for heating supply in the PRC, and 6 million in the core BTH area and Shandong Province by 2020. The Plan for Clean Heating in Northern PRC during Winter Season (2017–2021) targets (i) achieving a 70% clean heating ratio by substituting 150 million tce by 2021; (ii) prioritizing geothermal, biomass, and other clean energy sources for rural heating;

[14] Organisation for Economic Co-operation and Development and International Energy Agency. 2017.*Tracking Clean Energy Progress 2017*. Paris.

[15] International Energy Agency and Tsinghua University. 2017. *District Energy Systems in China: Options for optimization and diversification.* Paris.

[16] Government of the People's Republic of China, National Energy Administration. 2016. *13th Five-Year Plan for Development of Biomass Power*. Beijing.

[17] CECEP Consulting Co. Ltd. 2018. *China Biomass-To-Heat Development Strategy Research Project Final Report*. Beijing.

and (iii) improving building energy efficiency by renovating 50 million m^2 of rural buildings. The Government of the PRC has put a lot of efforts to achieve the targets, however, help is needed to leverage other resources to achieve the targets set in those plans.

12. In response to the issuance of the national plan, the Shandong Provincial Government launched its Provincial Plan of Air Pollution Prevention and Control for 2013–2020, which aims to reduce coal's share of primary energy consumption to 60% by 2020. In doing so, Shandong's Long-term Development Plan for New and Renewable Energy (2016–2030) targets (i) replacing15 million tons of coal for heating by 2020 and 30 million by 2030 with biomass wastes, and (ii) developing 4.35 million tce of geothermal energy for heating by 2020 and 8.7 million tce for cooling by 2030. The provincial government also released the Implementation Opinion on Promoting Rural Heating in 2017, which requires at least 70% of villages to be equipped with clean heating by 2020, and existing rural houses and public facilities to be renovated to reduce building energy consumption and improve energy efficiency.

3. ADB Sector Experience and Assistance Program

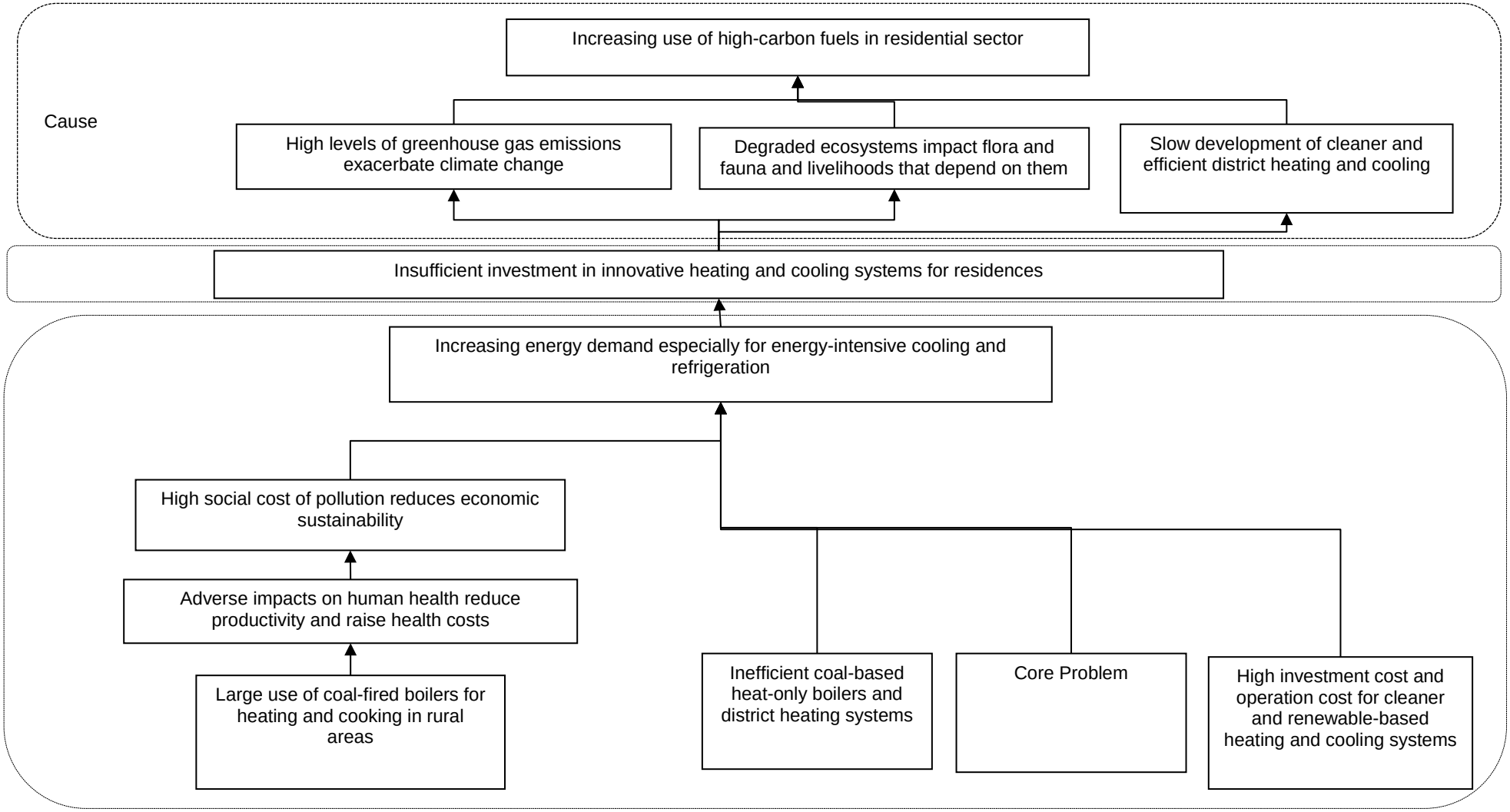
13. The Asian Development Bank (ADB) is one of the PRC's main development partners. During 2010–2015, ADB focused its energy sector experience on innovative low-carbon energy technologies, cleaner heating services in urban areas, and industrial energy efficiency by facilitating access to credit for better technologies. In the agriculture sector, ADB promoted environmental sustainability and climate change through projects supporting renewable biomass energy. ADB works closely with other bilateral and multilateral financial institutions to help address the air quality problem in the greater BTH region including Agence Française de Développement, the European Investment Bank, the International Finance Corporation, KfW, and the World Bank. The proposed project is the fourth in a multiyear, multisector ADB support program for air quality improvement in the greater BTH region. The first loan, which ADB approved in 2015, focused on policy reforms and strengthening regulatory capacity in Hebei Province.[18] The second loan, approved in 2016, targeted better access to finance, especially for small and medium-sized enterprises, to scale up investments in pollution reduction projects in the region.[19] The third loan, approved in 2017, aimed to deploy advanced technology to reduce air pollution from large emitters in the agriculture, energy, transport, and urban sectors.[20] This proposed project will help Shandong Province shift to cleaner and more efficient heating and cooling by integrating various clean and renewable energy sources.

[18] ADB. 2015. *Report and Recommendation of the President to the Board of Directors: Proposed Policy-Based Loan to the People's Republic in China for the Beijing–Tianjin–Hebei Air Quality Improvement—Hebei Policy Reforms Program.* Manila.

[19] ADB. 2016. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Air Quality Improvement in the Greater Beijing–Tianjin–Hebei Region—China National Investment and Guaranty Corporation's Green Financing Platform Project.* Manila.

[20] ADB. 2017. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Air Quality Improvement in the Greater Beijing–Tianjin–Hebei Region—Regional Emission-Reduction and Pollution-Control Facility.* Manila.

PROBLEM TREE



Source: Asian Development Bank estimates.