SECTOR ASSESSMENT SUMMARY: ENERGY

1. Sector Performance, Problems, and Opportunities

1. **Heating subsector overview.** The district heating system has grown rapidly in the People's Republic of China (PRC) since it was introduced in the 1950s after the First Five-Year Plan, 1953–1957. Currently, the PRC has the second largest district heating market in the world. The total coverage area of district heating systems in the PRC expanded from 2.2 billion square meters (m^2) in 2004 to 5.2 billion m^2 in 2012—an annual average rate of increase of 11.6%. Yet, district heating covers only 35% of the total heating area in the PRC compared with about 60% in European countries. Many areas still rely on inefficient and polluting coal-fired household stoves and small boilers. The demand for district heating continues to increase in tandem with economic growth and urbanization. The energy use in district heating increased from 1.9 exajoules in 2004 to 3.0 exajoules in 2012, accounting for an annual average increase of 5.4%. Based on the energy consumption and heating area growth of district heating systems, their energy intensity decreased from 0.90 gigajoules per square meter (GJ/m^2) in 2004 to 0.57 GJ/m^2 in 2012. However, compared to schemes in western and northern Europe, where the energy intensity is about 0.37 GJ/m^2, there is room to improve the energy efficiency of district heating in the PRC.

2. In Inner Mongolia Autonomous Region (IMAR), district heating coverage has also grown rapidly from 92 million m^2 in 2004 to 329 million m^2 in 2012—an annual average increase of 17.3%. Energy consumption also increased from 91 petajoules in 2004 to 199 petajoules in 2012, or an annual average growth rate of 10.5%. Thus, the energy intensity of district heating systems in IMAR decreased from 0.99 GJ/m^2 to 0.60 GJ/m^2 during the same period. However, the intensity is higher than the national average of 0.57 GJ/m^2 because of the longer heating season and lower outdoor temperatures.

3. The heating tariff is set by the price bureau of each province, and in most parts of the country, including IMAR, the fee charged is based on space rather than consumption. A nationwide heating subsidy scheme that targets low-income households is provided to make heating affordable. Residential buildings account for 70% of the district heating market, while commercial and public buildings make up the remaining 30%. Coal, the dominant heat source, gives rise to pollution that significantly damages the environment and people's health. A substantial portion of district heating systems in the PRC is aged and inefficient, and needs to be rehabilitated or replaced with clean, energy-efficient, modern systems.

4. **Heat energy sources.** Energy sources other than coal, such as natural gas, solar, wind, hydro, geothermal, biomass, shallow ground geothermal, and coal bed methane, can be used to provide hot water for space heating. Yet, some of these cleaner heat sources have limited application due to availability and location of sources. The financial implications of different heat sources are also a determining factor. Heavily populated and industrialized cities, such as Beijing and Tianjin, began to use natural gas in district heating because of serious concerns about the air pollution impacts of coal combustion.

5. IMAR has huge reserves of coal, but also is rich in natural gas, solar, and wind energy. IMAR's natural gas reserves, estimated at 834.4 billion cubic meters, account for 19% of the total natural gas reserves of the PRC.[1] The National Wind Power Information Center in the PRC

[1] The Statistics Bureau of the PRC estimated the proven natural gas reserves in the PRC at 4.4 trillion cubic meters in 2012, of which 834.4 billion cubic meters are in IMAR.

estimated that IMAR could achieve 380 gigawatts (GW) of wind energy installed capacity using current technologies, making this the biggest inland wind resource nationwide. The total wind installed capacity in IMAR is 18 GW. Considering the wind resource availability in IMAR, wind farms can operate for 2,800 hours per year and can produce 50.4 terawatt-hours of electricity. The Government of IMAR (GIMAR) plans to increase the installed wind power capacity to 50 GW by 2020. As combined heat and power plants are prioritized to supply power, many wind farms are forced to disconnect from the grid and valuable wind energy is wasted, particularly at night during wintertime when power demand is relatively low but wind power generation is high. As underutilization of wind power became a serious challenge for renewable energy development in the PRC, the National Energy Administration issued a notice in 2013 to urge the development of wind-to-heat projects in the Northern PRC.[2] The GIMAR is keen to promote wind-to-heat projects as a means to increase demand for wind power. A few pilot small-scale wind-to-heat projects are under construction or in operation.[3]

6. **Heat source technology options.** Natural gas is considered to be the cleanest fossil fuel energy source, yet it can produce nitrogen oxides (NO_X) emissions of 500 parts per million or more. Low-NO_X boilers are designed to reduce up to 85% of NO_X emissions by lowering the flame temperature, modifying the burner to create a larger flame (and therefore a lower temperature), injecting water or steam into the flame, recirculating flue gases, and/or limiting the excess air in the combustion process. It also lowers the carbon monoxide level. Ultra-low-NO_X boiler technology is still immature, expensive, and not commercially available in the PRC.

7. An electric boiler is a well-proven technology with key advantages such as (i) extremely quick response time, suitable both for cyclical or intermittent operations; (ii) clean firing without any combustion emissions, thus no stacks are needed; (iii) an efficiency level of more than 99%; (iv) low maintenance requirements; and (v) a smaller volume and footprint. A high-voltage, large-scale electrode boiler has a competitive advantage, as it requires a cheaper transformer and less space than a small, low-voltage electric boiler. Based on the heat source technology assessment, low-NO_X boilers with significant emission reduction, and high-voltage, large-scale electrode boilers have a smaller carbon footprint and are more suitable for larger district heating systems to serve urban residents in Hohhot City.

8. **Key subsector issues.** The key issues are summarized as follows:

(i) **Insufficient coverage of district heating.** Rapid economic growth and urbanization demands more district heating in many cities and county towns, where inefficient and polluting coal-fired stoves and small neighborhood boilers without adequate emission control prevail, causing local air pollution.

(ii) **High heat loss in heating network.** The National Energy Conservation's standard for the transmission efficiency of heating networks is 90%. Yet a report from Tsinghua University found 66%–68% efficiency in heating networks. Raising efficiency requires insulation improvement; leak protection, including detection

[2] Wind-to-heat projects are district heating projects that use energy from wind turbines to heat water in a huge kettle-like hot-water boiler. The use of wind power in district heating is not totally new technology. Scandinavian countries and the United Kingdom have wind-based district heating projects.

[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 with a heating coverage of 115,000 m^2 using low-voltage 2.16 MW boilers, Li Xi town in Chifeng City is constructing a 20 MW wind-to-heat project using high-voltage 10 MW boilers with a heating coverage of 126,000 m^2, and Siziwang County is also constructing a 52 MW wind-to-heat project using low-voltage 2.16 MW boilers with a heating coverage of 500,000 m^2.

devices; and sufficient and proper design based on thorough hydraulic analysis of the district heating transmission and distribution systems.

(iii) **Urban air pollution from use of coal.** Coal is the dominant heat source for district heating as it is readily available and economical. But, coal combustion emits significant amounts of carbon dioxide and other pollutants, which are major contributors to the poor urban air quality in wintertime. Big cities like Beijing, Tianjin, and others switched their heat source from coal to natural gas. Renewable and cleaner heat sources should be further promoted, where available.

(iv) **Need for strong government policy and financial support for cleaner, renewable-based heating systems.** Natural-gas-based heating systems with renewable energy integration are expensive compared to coal-based district heating. Strong government financial support is needed to fill the price gap for clean fuel. In the short run, the government should shoulder the environmental externality. In the medium and long term, the government should gradually adjust the heating tariff to enable increasing use of clean energy in district heating, taking into consideration (a) affordability of clean district heating services for consumers, (b) full cost recovery by heating companies for clean energy use, and (c) fair sharing of environmental costs among stakeholders.

(v) **Need for further public financing support.** A large portion of district heating systems in the PRC are aging and requires rehabilitation and/or upgrade to cleaner, and more efficient systems. District heating has a long investment cycle and has relatively low rates of return. Thus, for business viability, heating companies need to access to loans with lower interest rates and longer tenure.

2. Government Sector Strategy

9. **Government policy and targets.** The Twelfth Five-Year Plan, 2011–2015, targets a 16% energy intensity reduction, 17% carbon intensity reduction, 8% sulfur dioxide reduction, and 10% NO_X reduction for better urban and regional air quality. To meet these targets, the government introduced a series of policy measures in various subsectors, including heating. In 2007, the National People's Congress of the PRC amended the Energy Conservation Law, to require the implementation of household-based heat metering and consumption-based billing.[4] The National Development and Reform Commission (NDRC) and the Ministry of Housing and Urban–Rural Development (MOHURD), who is responsible for creating policies and regulations for energy conservation of building sector and the district heating subsector, issued the Urban Heating Price Reform Tentative Guideline in 2007 to guide local governments in setting appropriate heating tariffs.[5] Furthermore, the MOHURD—together with the NDRC, the Ministry of Finance, and the General Administration of Quality Supervision, Inspection and Quarantine—issued Comments on Further Enhancing Heating Metering Reform in 2010, which requires the implementation of consumption-based billing for newly completed buildings, and energy efficiency devices for existing buildings.[6] In addition, the State Council of the PRC issued 10 air pollution prevention and control measures, including reducing coal usage and increasing the utilization of natural gas and renewable energy in district energy systems. Also, the National

[4] Government of the People's Republic of China, National People's Congress. 2007. *Law of the People's Republic of China on Energy Conservation*. Beijing.

[5] Government of the People's Republic of China, National Development and Reform Commission and the Ministry of Housing and Urban–Rural Development. 2007. *Urban Heating Price Reform Tentative Guideline.* Beijing.

[6] Government of the People's Republic of China, Ministry of Housing and Urban–Rural Development. 2010. *Comments on Further Enhancing Heating Metering Reform.* Beijing.

Plan on New Urbanization, 2014–2020 promotes gas-based heating and wind power integration for clean heating systems in northern cities.

10. The GIMAR issued the Guidance on Reinforcement of Heating for Cities and Towns in 2009 to promote heat metering reform by defining the overall goal, main tasks, and detailed rules on heat-metering installation, temperature-control devices, and determination of heating tariffs.[7] It also issued the Special Plan for Energy Efficient Building under the Twelfth Plan of IMAR, targeting the rehabilitation of the existing 50 million m^2 heating area. The plan also regulated consumption-based heating payment for newly built and rehabilitated buildings, and the gradual enforcement of this scheme starting with large public buildings equipped with heat-metering devices.

3. ADB Sector Experience and Assistance Program

11. During the Twelfth Plan period, the Asian Development Bank (ADB) played a leading role among international donors in supporting technology and market innovations in the district heating subsector. ADB approved two loans for district heating, totaling about $250 million, to Heilongjiang and Shanxi provinces.[8] The World Bank is also active in this subsector, and has provided a loan of about $200 million to Shanxi Province and Xinjiang Uygur Autonomous Region.[9]

12. ADB's Energy Policy prioritizes energy efficiency and access to energy for all.[10] The country assistance program evaluation for the PRC indicated that projects focused on energy efficiency improvements, renewable energy, and environmental concerns appropriately add value and contribute to PRC priorities.[11] The district heating subsector is recognized as an area for improving energy efficiency and increasing access to modern heating services. ADB will support (i) energy efficiency improvement in district heating for the development of low-carbon cities; (ii) provision of modern and reliable heating services essential for sustainable human development, economic growth, improved quality of life, and better delivery of education and health services in regions with long, harsh winters; and (iii) reform in the district heating subsector, including tariff and billing reform for energy conservation and private sector participation.

13. Start-up delays have occurred in previous ADB-funded district heating projects, because of (i) slow mobilization of a domestic tendering company, and (ii) delay in concluding onlending agreements resulting in slow opening of a project imprest account. Learning from past experience, these issues can be addressed by (i) ensuring early mobilization of a tendering company; (ii) starting detailed design before loan effectiveness, and (iii) concluding onlending agreements before loan effectiveness.

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[7] Government of Inner Mongolia Autonomous Region. 2009. *Inner Mongolia Autonomous Region Government's Guidance on Reinforcement of Heating for Cities and Towns, IMAR Government No.232*. Hohhot.

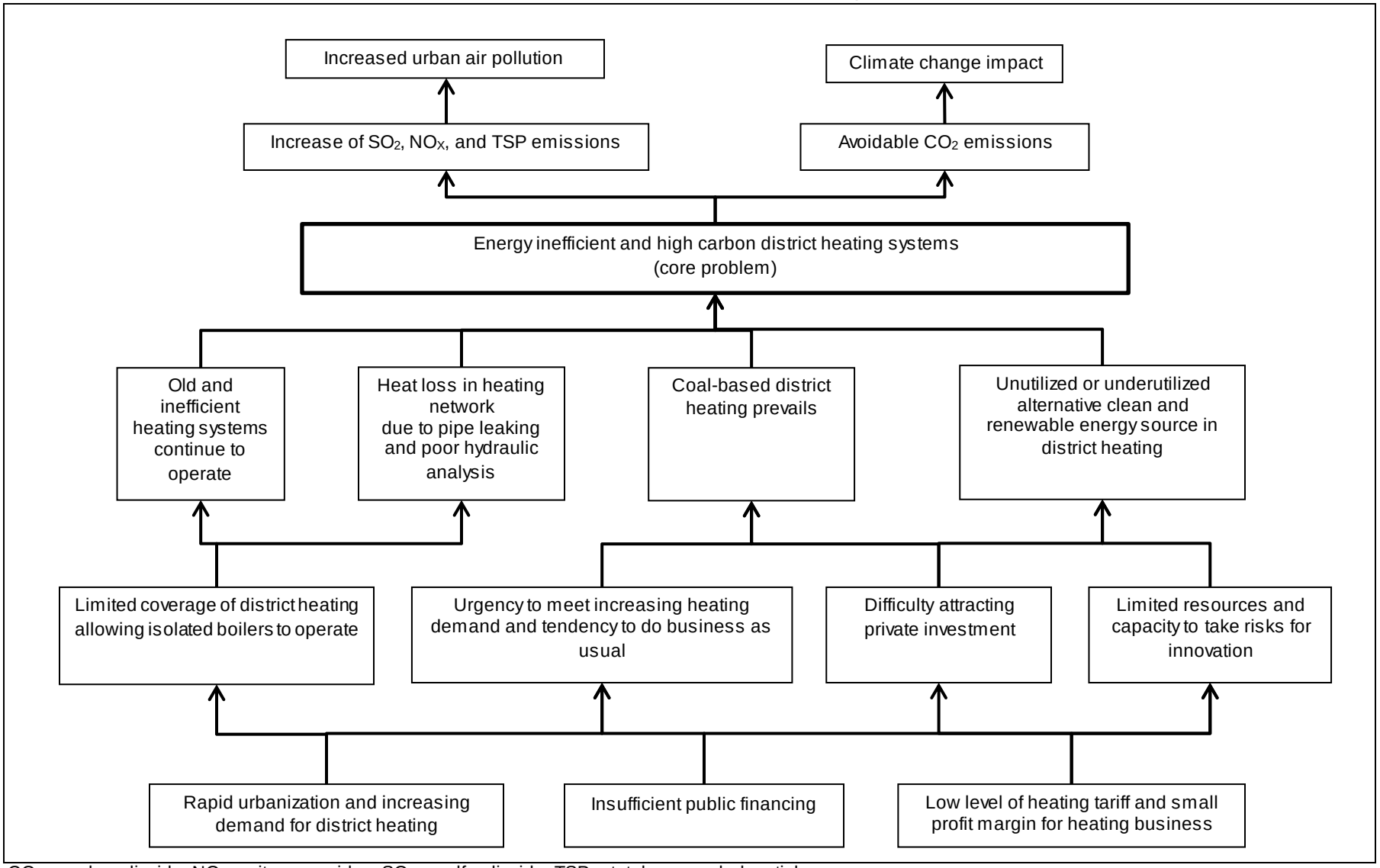
[8] ADB. 2012. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Heilongjiang Energy Efficient District Heating Project*. Manila (Loan 2898-PRC, approved on 25 September, for $150 million); ADB. 2012. *Report and Recommendation 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 (Loan 2885-PRC, approved on 31 August, for $100 million).

[9] World Bank. 2014. *Shanxi Gas Utilization Project*. Washington, DC (P133531, approved on 28 March, for $100 million); World Bank. 2011. *Urumuqi District Heating Project*. Washington, DC (P120664, approved on 17 May, for $100 million).

[10] ADB. 2009. *Energy Policy*. Manila.

[11] ADB. 2007. *Country Assistance Program Evaluation: People's Republic of China*. Manila.

Problem Tree for District Heating



CO_2 = carbon dioxide, NO_x = nitrogen oxides, SO_2 = sulfur dioxide, TSP = total suspended particles.
Source: Asian Development Bank estimates.

Sector Results Framework (Energy, 2011–2015)

Country Sector Outcomes		Country Sector Outputs		ADB Sector Operations	
Outcomes with ADB Contribution	**Indicators with Targets and Baselines**	**Outputs with ADB Contribution**	**Indicators with Incremental Targets**	**Planned and Ongoing ADB Interventions**	**Main Outputs Expected from ADB Interventions**
Improved energy efficiency and reduced emissions	Carbon intensity reduced by 17% from 2010 levels (2010 baseline: 8.1 billion tons of carbon dioxide (CO_2) and CNY40,151 trillion of gross domestic product [GDP]) Energy consumption per unit of GDP reduced by 16% from 2010 levels (2010 baseline: 3.25 billion tons of coal equivalent (tce) and CNY40,151 trillion of GDP) Share of nonfossil fuels in primary energy consumption reach 11.4% by 2015 (2010 baseline 8.3%)	Financing for energy efficiency in energy-intensive provinces, such as Guangdong, Hebei, and Shandong, scaled-up Greenhouse gas emission intensity from fossil fuel power plants reduced by innovative technologies such as integrated gasification combined cycle (IGCC) and carbon capture and storage New renewable energy technologies, such as concentrated solar thermal, grid-connected solar photovoltaic, and offshore wind, demonstrated Functioning cap-and-trade-based emission trading market piloted and demonstrated	Achieve 18% reduction in energy intensity in Guangdong, Hebei, and Shandong provinces by 2015 compared with 2010. Demonstrate the IGCC technology and carbon capture and storage in fossil fuel power plants. Demonstrate concentrated solar thermal, offshore wind, and grid-connected photovoltaic plants for a total capacity of 200 megawatts (MW) by 2015. Pilot and demonstrate smart grid to enable a larger share of renewable energy in the mix. Pilot test and demonstrate a functioning carbon market in a key province or city.	**Planned key activity areas** • Energy efficiency improvement in industrial and district heating • Demonstrating new renewable energy technologies • Low-carbon fossil fuel power plant technologies **Pipeline projects with estimated amounts** (2014–2015) • Low-Carbon District Heating Project in Inner Mongolia Autonomous Region (IMAR) ($150 million) • Gansu Jinta Concentrated Solar Power Project ($100 million) • Chemical Industry Energy Efficiency and Emission Reduction Project ($100 million) • Qingdao Smart Low-Carbon District Energy Project ($130 million) **New renewable energy technology projects** • Scaled-Up Energy Efficiency Investment Program **Ongoing projects with approved amounts** • Hebei Energy Efficiency Improvement and Emission Reduction Project ($100 million) • Heilongjiang Energy-Efficient District Heating Project ($150 million) • Shanxi Energy Efficiency and Environment Improvement Project ($100 million) • Inner Mongolia Autonomous Region Environment Phases I and II ($270 million) • Guangdong Energy Efficiency Project ($100 million) • Shandong Energy Efficiency Project ($100 million) • Tianjin Integrated Gasification Combined Cycle Power Plant Project ($135 million) • Qinghai Delingha Concentrated Solar Thermal Power ($150 million)	**Planned key activity areas** •Energy savings of over 600,000 tce/yr and emission savings of more than 1.5 million tons per year achieved from energy efficiency projects financed by ADB by 2015 •Commissioning of 200 MW of new renewable energy technologies by 2015 supported •Carbon capture and storage successfully demonstrated in a commercial-scale project **Pipeline projects** •A low-carbon district heating system implemented in Hohhot City •A 50 MW concentrated solar power plant with thermal storage including a natural gas back-up system constructed in Gansu Province. •Energy efficiency improved and emissions reduced from the chemical industry. •Smart low-carbon district energy system in Qingdao City demonstrated. **Ongoing projects** •Industrial energy efficiency projects and energy service company projects implemented •Improved energy efficiency and a cleaner environment in Heilongjiang and Shanxi provinces, and IMAR. •Successful commercial-scale IGCC technology demonstrated. •Energy savings of over 300,000 tce per year achieved through projects in Guangdong and Shandong provinces. •First-of-its-kind utility scale concentrated solar thermal plant in Qinghai province constructed.

Source: Asian Development Bank cost estimates.