THE WORLD BANK

Shandong Province IBNET Urban Water Assessment
The World Bank (Japan Trust Fund) Financed Technical Assistance – TF030802

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EXECUTIVE SUMMARY

Introduction & Background
The World Bank in partnership with the Water and Sanitation Programme and the British Department for International Development (DFID) have established the International Benchmarking Network for Water and Sanitation Utilities (IBNET) initiative (www.ibnet.org). The objective of IBNET is to support access to comparative information that will help to promote best practice among water supply and sanitation providers worldwide and eventually will provide consumers with access to high quality, and affordable water supply and sanitation services.

As part of the IBNET initiative PADECO Co., Ltd was commissioned by the World Bank under the Japan Trust Fund to conduct a survey and analysis of water services in the Shandong Province, China. This report presents the results of this survey and analysis. A soft copy of the survey and performance indicator database is provided separately.

Shandong Province on the eastern coast, is one of China’s fastest growing and most prosperous economic regions with a strong demand for high quality water services, but is an area with limited natural water resources.

Data Quality
29 water companies out of the 109 water companies in Shandong Province participated in this benchmarking survey, providing data on around 100 parameters over three years of operation. 50 Key Performance Indicators were evaluated and analyzed.

Adequate data confidence is a very important aspect of this data collection and evaluation process and fundamental in providing quality assurance of the benchmarking system.

It is concluded that the data collection has been well managed, the data inputs have sufficient accuracy based on data available to each water company and, overall, are consistent with the water company records, and as such is satisfactory for the purpose of this study. The confidence grading, however, seems over confident due to its subjective nature.

Analysis and Evaluation
The analysis and evaluation of the IBNET survey and benchmarking results found considerable variation in the size of business operations among the surveyed water companies. Therefore, to facilitate analysis and evaluation, the water companies were grouped in accordance with their population:

- Towns: population less than 100,000
- Small cities: populations between 100,000 and 500,000
- Medium cities: population between 500,000 and 1 million
- Large cities: populations larger than 1 million

The IBNET benchmarking survey found that the overall conditions for Water Services in the Shandong Province represented many examples of good practice and effective service.

Key findings
The IBNET indicators survey proved to an important tool for the assessment of the water services in China. In particular the survey provided management with indicators that measure their
business performance and provides new tools for monitoring and controlling future business performance. For example the survey highlighted good practice being carried out by the participating utilities and also highlighted areas of business where there is potential scope for efficiency gains.

Urban population density is high, compounded by rapid urban growth. A primary challenge for all the water companies is expanding services to meet the consequent demand. Larger cities have been expanding their network at around 3 to 5% per year. However, this challenge is considerably harder for smaller water companies that are having to expand networks at up to 11% per year, but with considerably less access to fiscal subsidies and less power to ensure adequate revenues to cover expenditures.

Non Revenue Water as a percentage is low, which is attributed to high population densities in the urbanized areas creating a high efficiency and recently installed distribution networks. But actual physical losses (in cubic meters per km) and number of breaks per km of the network are close to the poorer performing countries of the former USSR. Therefore, substantial efficiency gains may be achieved through improvements in operational management of the distribution network such as pressure monitoring and pressure control and through targeted NRW reduction programmes. Specific effort should be put into monitoring and recording incidences of pipe bursts in accordance with location, pipe material, pipe diameter. Analysis of this data will allow informed prioritization of future NRW reduction programmes.

Up to 50% of potable water is consumed by non-residential users. In many places these industrial & commercial users are receiving preferential services from the water companies. However, these industrial & commercial users also cross-subsidize domestic users.

Financial balance of water services is consistent with the underlying premises of the political and economic system of the People’s Republic of China. Social policy dominates in the decision process — tariffs are low, and debts are written off at the end of the year. Small water utilities are in a much worse financial situation than large and medium utilities, as they perhaps have much less political power that their peers in large cities to increase tariffs or impose cross subsidies and rate of cross-subsidization is growing.

An essential step for water companies to ensure self-sufficiency is ensuring transparency of the capital and operational expenditures required to provide a safe and reliable water service. This transparency will assist water companies in quantifying and justifying the necessary increases in water bills to end consumers.

Therefore, financial flows into the sector need to be studied, especially to increase transparency in the provision of funds for system development and network expansion, which are currently provided through municipality sources with limited contribution from the water sectors revenues. In the long-run the financing system of the water services investments and perhaps debt service cannot be considered as sustainable as a substantial proportion of expenditures arise from sources (namely fiscal sources) that are outside of the municipal water sector’s control.

In conclusion, repeating the survey annually and also expanding the survey to more utilities will strengthen the reliability of the database to the benefit of all participating utilities.
GLOSSARY OF TERMS

BOD  Biochemical oxygen demand
DfID  British Department for International Development
ECA  Europe and Central Asia region
GDP  Gross Domestic Product
IBNET  International Benchmarking Network of Water and Wastewater Utilities
IFI  International Finance Institutions
Japan CTF  Japanese Consultant Trust Fund
Lcd  Litres per capita per day
MAC  Maximum Allowable Concentration
MoF  Ministry of Finance
m$^3$/s  cubic metres of water flowing per second
NEAP  National Environmental Action Plan
O&M  Operation and maintenance
SWA  Shandong Water Association
TA  Technical Assistance
TDS  Total Dissolved Solids
USD  United States Dollars
WHO  World Health Organisation
WSP  Water and Sanitation Programme
WTP  Water Treatment Plant
WWTP  Wastewater Treatment Plant
KPI  Key Performance Indicator
NRW  Non Revenue Water
GNI  Gross National Income
RMB  Renminbi (Chinese RMB )

The exchange rate used in this study was 1 Chinese RMB (RMB) = US$0.125.
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1. INTRODUCTION

Benchmarking is an important tool to provide information to a range of stakeholders about utility and sector performance, at national, regional and international level. The goal of the International Benchmarking Network of Water and Wastewater Utilities (IBNET) is to improve service delivery by utilities through the provision of international comparative benchmark performance information to a wide range of stakeholders. IBNET is designed as a system with low barriers to participation, easy to use and provides users with access to performance results, and background information on benchmarking.

In the past few years, the World Bank took steps to develop such an international benchmarking system by trying to reduce the key barriers that make comparisons difficult. To that effect, the Bank has worked to develop a suite of software that facilitates benchmarking through a standard set of indicators. The IBNET team conducted many studies around the world and these studies are consolidated at the www.ib-net.org website.

The Water and Sanitation Programme (WSP) and with the support from Japanese Consultant Trust Fund (Japan CTF) commissioned PADECO Inc. to conduct a survey and analysis of water services in the Shandong Province, China. The data were presented by 30 water companies covering about 80% of the municipal population of the province.

The survey and analysis was conceived and designed through the collaboration of the World Bank, the Urban Department of Construction and the Finance Department of Shandong Construction Commission. The authority and commitment of these institutions is currently fundamental to ensuring participation of water companies.

The Shandong Water Association has been diligent in the management of data collection, filing, auditing and pursuing remedial data collection. The technical competence and efforts of the SWA staff have assisted in this. The SWA maintains good relationships with its member companies and is well respected. Consequently, the SWA would be an appropriate institution for carrying out future surveys and performance benchmarking analysis.

The World Bank team and PADECO would like to acknowledge the following parties for their respective valuable contributions to enable the successful production of this study.

- Mr. FENG Lancheng, Finance Department of Shangdong Construction Commission
- Mr. WANG Guan, Urban Department of Construction Department
- Mr. DONG Ming Cai, Shandong Water Association
- Ms. ZHANG Hui, Shandong Water Association
- Mr. Li BO, WB-ADB Shandong Province Project Management Office
- Dr. Joe ZHAO, Consultant, Director of ESD China Ltd.
2. BACKGROUND

2.1 Geography of Shandong Province

The Shandong Province is approximately 700 kilometers from east to west and approximately 420 kilometers from north to south; the total land area is around 156,700 square kilometers, approximately 1.6% of the national total land area. (See the map on Figures 1 and 2). The province’s relief is predominantly flat with the northwestern, western, and southwestern areas being part of the greater North China Plain, with around 63% of the total area being plain. The most prominent mountains are in the centre of the province (Taishan Mountains, Lushan Mountains, and Mengshan Mountains) while the hilly Shandong Peninsula extends east into the sea, around 34% of the total area is mountainous. The remaining 3% of land area is freshwater lakes. Shandong Province has a coastline of 3,024 kilometers.

The Yellow River flows through Shandong’s western area on a raised levee to the province’s northern seacoast. The Grand Canal of China enters Shandong from the northwest and leaves on the southwest. Lake Weishan is the largest lake of the province.

Shandong has a warm temperate climate, with four distinct seasons, moist summers and dry, cold winters. Average temperatures are -5 to 1 °C in January and 24 to 28 °C in July. Annual precipitation is between 550 to 950 mm.

Water resources of Shandong mainly come from precipitation. The average total volume of natural water resources in the province is 37.95 billion cubic meters. The Yellow River is the major source of incoming water flows to Shandong, with an average runoff volume to 43.67 billion cubic meters. In view of the province as a whole, Shandong is relatively poor in water resources, with a per capita water resource volume of only 344 cubic meters/person, equivalent to 16 percent of the national per capita volume and 4% of the world per capita volume.

The reported total population is nearly 91.8 million (2004 estimate), with an urbanized population of around 43%. The 17 prefecture-level divisions of Shandong are subdivided into 140 county-level divisions (49 districts, 31 county-level cities, and 60 counties). Those are in turn divided into 1941 township-level divisions (1223 towns, 293 townships, 2 ethnic townships, and 423 subdistricts).

Figure 1: Map of the People’s Republic of China highlighting the location of Shandong Province
2.2 Economy of Shandong Province

Shandong is one of the more affluent provinces of China, in 2004, the nominal GDP for Shandong was 1.55 trillion RMB (US$192.3 billion), ranking second in the country (behind Guangdong). Contribution to GDP is summarized as:

- Primary industry contributes around 178 billion RMB (US$22 billion)
- Secondary industry contributes around 872 billion RMB (US$109 billion)
- Tertiary industry contributes around 499 billion RMB (US$62 billion)

The per capita output was around 16,925 RMB (US$2,116) in 2004. Total imports and exports exceed 60 billion US dollars. Given the above scale of industrial activity, the province has one of the highest levels of tax revenues among the Chinese provinces of around 229 billion RMB (US$29 billion).

Economic development has focused on large enterprises with well-known brand names. Shandong peninsula and coast has also benefited from South Korean and Japanese investment, due to its geographical proximity to those countries. Qingdao City is home to two of the most well-known brand names of China: Tsingtao Beer and Haier. In addition, Dongying’s oil fields and petroleum industries form an important component of Shandong’s economy. In contrast, western Shandong relies on rural, agricultural economy.
3. METHODOLOGY OF DATA SURVEY AND ANALYSIS

The methodology used for training participants in the use of the IBNET toolkit, data collection and analysis is described in Appendix A.

Through discussion with the World Bank, the Shandong Construction Commission and the Shandong Water Association (SWA), 50 water companies were initially invited to participate in this study. Through the persistent efforts of the SWA, 29 water companies participated in this study.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Population, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bizhou Municipal Water Company</td>
<td>360</td>
</tr>
<tr>
<td>Dezhou Water Supply Corp.</td>
<td>406</td>
</tr>
<tr>
<td>Gongying Municipal Water Company</td>
<td>150</td>
</tr>
<tr>
<td>Gaomi Municipal Water Company</td>
<td>204</td>
</tr>
<tr>
<td>Heze Municipal Water Company</td>
<td>360</td>
</tr>
<tr>
<td>Jiaonan Municipal Water Company</td>
<td>321</td>
</tr>
<tr>
<td>Jimo Municipal Water Company</td>
<td>450</td>
</tr>
<tr>
<td>Jinan Water Supply LLC</td>
<td>2,000</td>
</tr>
<tr>
<td>Jining Water Supply Group Company</td>
<td>420</td>
</tr>
<tr>
<td>Jiyang County Water Company</td>
<td>63</td>
</tr>
<tr>
<td>Laiwu Municipal Water Company</td>
<td>230</td>
</tr>
<tr>
<td>Qingdao Laixi Municipal Water Company</td>
<td>210</td>
</tr>
<tr>
<td>Liaocheng Municipal Water LLC</td>
<td>367</td>
</tr>
<tr>
<td>Linyi Municipal Water Company</td>
<td>545</td>
</tr>
<tr>
<td>Penglai Water Supply Corp.</td>
<td>135</td>
</tr>
<tr>
<td>Qingdao Pingdu Municipal Water Company</td>
<td>250</td>
</tr>
<tr>
<td>Pingyin County Water Company</td>
<td>80</td>
</tr>
<tr>
<td>Qingdao Municipal Water Group LLC</td>
<td>1,660</td>
</tr>
<tr>
<td>Rizhao Municipal Water Company</td>
<td>249</td>
</tr>
<tr>
<td>Shengliyoutian Water Company of &quot;Victory&quot; Oil LLC</td>
<td>960</td>
</tr>
<tr>
<td>Taian Municipal Water Company</td>
<td>600</td>
</tr>
<tr>
<td>Weifang Municipal Water LLC</td>
<td>800</td>
</tr>
<tr>
<td>Yantan Municipal Water Company</td>
<td>708</td>
</tr>
<tr>
<td>Yiyuan County Water Company</td>
<td>89</td>
</tr>
<tr>
<td>Yucheng Municipal Water Company</td>
<td>110</td>
</tr>
<tr>
<td>Zaozhuang Water Supply Corp.</td>
<td>395</td>
</tr>
<tr>
<td>Zhangqi Municipal Water Company</td>
<td>140</td>
</tr>
<tr>
<td>Zibo Water LLC</td>
<td>130</td>
</tr>
<tr>
<td>Zouchang Municipal Water Company</td>
<td>246</td>
</tr>
</tbody>
</table>

The companies in the sample represent two larges utilities, Jinan and Qingdao, three county water companies and the Shengliyoutian Water Company of "Victory" Oil LLC and 14 municipal water companies of the different status.

Case studies of two contrasting cities (Jinan – an inland city with a population of around 2 million and Gongying – a coastal city with a population of around 150,000) were documented to demonstrate how the Benchmarking toolkit can be used to evaluate performance. To facilitate analysis, the companies are grouped in accordance with the population in the area served:

- Small cities: population less than 100,000
Medium cities population between 100,000 and 500,000
Large cities population between 500,000 and 1 million
Mega cities population larger than 1 million

3.1 Data Quality

In accordance with the INBET quality management instructions, confidence grades based on the reliability of data (A, B, C or D) were requested to each item inputs. Water Companies were responsible for assignment of grades. Assignment of grades was checked during the Quality Assurance audit to identify deviations from the agreed methodology.

Data confidence is considered as a very important aspect of any data collection and evaluation process and fundamental in a quality assurance for a benchmarking system. The grades are defined as follows:

Grade A = Audited data
Grade B = Reliable data
Grade C = Uncertain data
Grade D = Estimate, no data

During the training workshop, the consultant team provided guidelines on how to assign data quality grades to each item:

Grade A Regulated data that are available in printed documents like the tariffs
Grade B Data backed by some printed documents
Grade C Data that are only collected without printing documents backup and turn out to be in conflict with other data
Grade D Estimated data, based on experience and professional judgment

The water companies submitted an electronic copy of the questionnaire and a hard copy of the questionnaire. The hard copy of the questionnaire was stamped with the official chop of the water department (an example is given in appendix B) and submitted with official water company records.

In addition to quality checking of each item inputs for 30 questionnaires, four water companies’ questionnaires, Qingdao, Rizhao, Laiwu and Yantai were reviewed in detail and the PI inputs with the Confidence Grade A were checked against with the original water company records.

It is concluded that the data inputs have sufficient accuracy based on data available to each water company and consistent with the water company records. The confidence grading, however, seems over confident due to its subjective nature.

As a common practice in China, water companies have no statistical data for population per connection or household size. Consequently, the PIs calculated from numbers of connections are difficult to justify. Also it was difficult to differentiate urban populations and the populations served with public water supplies as census is frequently out-of-date or inaccurate. Moreover, the rapid growth of urbanization in Shandong Province like most developed regions in China makes historical data unreliable. Another elements is that water companies have no incentive to disclose performance data as there is weak regulatory enforcement or inadequate water monitoring facilities.

However, despite of all these difficulties, the overall, the data collection has been well managed, and the data quality is representative of records and as such is satisfactory for the purpose of this study with an adequate confidence grading.
4. RESULTS AND DISCUSSION

4.1 Demographics

Figure 3 below shows demographic trends in the areas served by each water company. Most companies are facing a substantial population increase in their areas of responsibility. The survey reported a higher total population in the areas surveyed than the 2000 census data. The population of the surveyed water companies grew from 11.3 million in 2003 to around 13.0 million in 2005, or 15% increase.

Urbanization development was reported to have been most rapid in the east of Shandong Province, especially in Qingdao, Yantai and Donging. Thus the main objective of the municipalities was to accommodate new comers and prevent establishment of illegal housing within the limits of municipality. A reflection of these demographic trends is that the length of the network that grew by 8-30% a year, with the highest rate in medium cities.

![Figure 3: Population in areas served by each water company](image)

4.2 Water coverage

During the period 2003-2005, there were no significant changes in water coverage ratio in most cities and there is no significant variation in the results obtained in relation to the size of the city. The average values were:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Water Coverage (%)</td>
<td>99</td>
<td>95</td>
<td>94</td>
</tr>
</tbody>
</table>

Shandong reported 90% of water coverage on average. At the same time utilities were able to accommodate about 400,000 new consumers.

As a basis for comparison, the National 2010 Water Supply Master Plan reported that: in China
East Region (coastal cities) in 2002, the average urban water supply coverage was 86%; in the Middle Region of China, 76%; and in the Western Region, 61%; in megacities, 87%, in large cities with population above 1 million 90%. The National 2010 Water Supply Master Plan proposes an average urban water coverage for 2010 of 92%. In this context, Shandong Province is clearly a leader in providing water services in the Chinese water industry.

Zibo Municipal Water Company has the lowest water supply service coverage of about 31% that is mainly attributed to a discrepancy in the population of the town in comparison to the population served (Zibo city has another three water supply companies, each serves a separate different districts, and the participated company is only one of them, while other three water companies declined to participate in the study). Additionally, further investigation has revealed that Zibo has wide usage of groundwater from private self-owned wells by residents and industries.

All utilities reported very high rates of population per network km — all above 1,000 people per km, 1,300 on average for the sample and above 3,000 people per km of the network in large cities. The closest example can be found in Vietnam, Indonesia and Zambia; however the average value of this indicator does not exceed 1,000 people per network km in these countries. Comparing with other large countries, in Brazil the density is in a range from 300 to 700 of consumers per km of pipe in very large cities, and in Europe and Central Asia region (ECA) it is about 200-300 in large cities. Such high density of population puts Chinese utilities in a unique situation: on the one hand they experience unprecedented economies of scale; however such high density may stress the water network and may require more intensive maintenance and more frequent replacement of the network.

4.3 Water consumption

The table below shows average values for total water consumption and residential consumption on a per capita basis. Demand on a per capita basis has been fairly constant, however, residential consumption is typically around 40% of total consumption.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Total Water Consumption (l/person/day)</td>
<td>223</td>
<td>222</td>
<td>207</td>
</tr>
<tr>
<td>4.7 Residential Consumption (l/person/day)</td>
<td>86</td>
<td>89</td>
<td>82</td>
</tr>
</tbody>
</table>
Figure 4 shows per capita daily water consumption in each area. Water consumption varies considerably from the lowest value of less than 50 lpcd to over 500 lpcd.

In some cities, such as Shengliyoutian (oil refining center of the province) and Rizhao, the water consumption is as high as 334 lpcd and 514 lpcd, respectively. The ratio of Industrial & Commercial Consumption to total consumption in both cities are 58% and 70%, respectively, which demonstrate that industrial/commercial water usage does significantly contribute to high water production per capita.

Heze WSC has the lowest consumption, 47 lpcd in 2005. Further review of Heze information found that groundwater from private wells is widely used which results in lower demand of public water supply.

Figure 5 below shows that in all water utilities the proportion of water consumed by residential users in comparison to industrial users consumption is relatively low (on average 45% of total consumption is by residential users, and in 20 utilities out of the 29 surveyed utilities, less than 50% of water is consumed by residential users). From an international perspective such consumption and revenue patterns are relatively rare for utilities of this scale of operation, appearing only in several cities of Russia built around large industries, which usually are the owners of water intakes or wastewater treatment plants that serve both an industrial plant and a municipality.

As discussed later, these high ratios have a bearing on cross-subsidies by industrial users of domestic consumers water bills.
Figure 5: Industrial & Commercial Consumption as a Percentage of Total (2005)

Figure 6 below presents an international comparison of per capita total daily consumption rates and per capita residential daily consumption rates. Shandong Province’s per capita total daily consumption rate of around 200 lpcd is similar to those found in similar emerging economies. However, residential consumption is around 80 lpcd, which is considerably below the presented peers.
Figure 6: International Comparison of Per Capita Consumption Rates (2004)
4.4 Water metering, non-revenue water and pipe breaks

Almost all water users are metered as a common practice. The table below shows average values for proportion of water sold that is metered.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1 Proportion of water sold that is metered (%)</td>
<td>99</td>
<td>99</td>
<td>100</td>
</tr>
</tbody>
</table>

The table below shows average values for Non Revenue Water.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Non Revenue Water (%)</td>
<td>20</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>6.2 Non Revenue Water (m3/km/day)</td>
<td>77.4</td>
<td>85.7</td>
<td>95.4</td>
</tr>
</tbody>
</table>

Figure 7 presents Non Revenue Water on a percentage basis.

Zibo reported the highest Non Revenue Water of 73% in 2005; this corresponds with a reported large decrease in the total volume of water sold to both domestic and industrial users. Cities with Non Revenue Water of less than 10% in 2005 are Penglai (10%), Jimo (8.6%), Liaoqian (2.7%), and. In 2005, six cities have Non Revenue Water of less than 15%, while seven cities Non Revenue Water have near or more than 30%. The top six utilities are recording Non Revenue Water performance is close to the best performing utilities of the UK and ECA.

Figure 8 presents a Non Revenue Water on the basis of cubic metres per kilometer per day.
The mega-cities of Jinan and Qingdao have extensive networks in excess of 1,000 km. Jinan has a Non Revenue Water of around 120 m³/km/day and 30% in 2003 increasing to around 160 m³/km/day and 34% in 2005. Qingdao has a Non Revenue Water of around 102 m³/km/day and 17% in 2003 increasing to around 112 m³/km/day and 15% in 2005. The daily NRW per unit length of pipeline is relatively high, especially considering that the population density in these urbanized areas is also very high. However, Qingdao has achieved a better performance, indicating that there may be some good practices being carried out.

Among the large cities, Taian has a poorer performance than the other large cities, with Non Revenue Water of 27% and 95 m³/km/day recorded, while also having the smallest network in this grouping.

Among medium sized cities, Zoucheng, Laiwu and Yucheng show poor performance in Non Revenue Water measured as a percentage, with averages of 35%, 41% and 30%, respectively. However, Non Revenue Water measured on the m³/km/day basis finds Laiwu, Gaomi and Zhangqui and Yucheng to have poorest performance, with averages of 142 m³/km/day, 138 m³/km/day, 79 m³/km/day and 60 m³/km/day, respectively. Both Laiwu and Yucheng have relatively small networks.

Among the small cities, Jiyang shows a relatively good Non Revenue Water performance on a percentage basis in comparison with similar sized cities, achieving an average of 9%. However, on the m³/km/day basis, Yiyuan has the best Non Revenue Water performance, achieving an average of 45 m³/km/day.

A summary is given in the table below. Many of the water supply companies have high physical losses of around 50 — 90 m³/km/day; and in the mega-cities around 150 m³/km/day. For comparison, in the UK this indicator is close to 10 m³/km/day and in Hungary it is 35 m³/km/day. In Brazil, only Rio de Janeiro reports similar losses per km of the network but this also
corresponds to a much higher percentage non-revenue water (about 55%).

<table>
<thead>
<tr>
<th></th>
<th>Non-RevenueWater, 2005 (%)</th>
<th>Non-RevenueWater, 2005 (m3/km/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega-cities</td>
<td>26%</td>
<td>120</td>
</tr>
<tr>
<td>Large cities</td>
<td>27%</td>
<td>80</td>
</tr>
<tr>
<td>Medium cities</td>
<td>19%</td>
<td>120</td>
</tr>
<tr>
<td>Small cities</td>
<td>21%</td>
<td>59</td>
</tr>
<tr>
<td>Average</td>
<td>26%</td>
<td>95</td>
</tr>
</tbody>
</table>

The opportunity cost of Non Revenue Water for one of the larger cities is clearly presented in Figure 9 below. For every 1% reduction in NRW, the water company has the potential to receive an additional revenue of 4,545,000 RMB/year (US$0.57 million/year), this assumes that there is bankable demand for the additional water made available.

![Figure 9: Example of Potential Gains from reducing Non Revenue Water](image)

Consideration of the methods for determining Non Revenue Water and also the causes of Non Revenue Water will assist putting the above results into context:

- Non Revenue Water on a percentage basis is determined as a ratio of the annual volume of water produced and the annual volume of water for which revenue is received.
- Non Revenue Water on a cubic meter per kilometer per day is determined as the difference between annual volume of water produced and annual volume of water for which revenue is received divided by total network length.

While non-revenue water is caused by three elements, namely:

- **physical leakage** - The high population densities in Shandong’s urban areas result in capital
efficient distribution networks, but requires large diameter supply mains and high capacity water distribution networks that operate with high pressures and high volumetric flow rates. When leaks occur, the volumetric rate of loss will be considerably higher than for low pressure and low capacity systems.

- **Illegal water use** – to differentiate illegal water use from physical leakage requires considerable data gathering and analysis. However, the high level of metering, low cost of water, stiff penalties and availability of groundwater all act as disincentives for illegal water use. The main incentive for illegal water use is access to a pressurized supply of cleaner water than groundwater. Through informal discussions, local water staff suggested that illegal water use was probably less than 5% of total production.

- **Uncollected revenues** – this is discussed in more detail in the case studies in Chapter 5.

Physical leakage is considered to be the main cause of Non Revenue Water. These results suggest that there substantial differences in the conditions of the water distribution networks which may reflect examples of good practice in terms of network management, maintenance and renewal planning and implementation. Water companies with poor performance should be encouraged to review the activities of similar cities to identify examples of good practice.

Activities that are likely to offer significant reductions in NRW include strengthening the operational management of the distribution network through improving operations management training, pressure monitoring and pressure control, together with targeted NRW reduction programmes.

A major cause of physical leakage is pipe bursts, identifying locations & causes of pipe bursts and preventing future pipe bursts should be included as an element of NRW reduction programmes. Bursts include failures on mains and service pipes where they are the Utility’s responsibility; therefore in this study the breaks of smaller pipes (less than 100 mm in diameter) are not included in the computation of this indicator. Many water companies do not record pipe breaks against the diameter of the broken pipe, consequently differentiating break records in pipe diameters over 100 mm was not possible.

The mega-cities with extensive networks show very low number of pipe breaks per year, this is presumed to be due the majority of network being recent construction. Among the medium sized cities, Yucheng, Zhangqiu, Weihai, Jiaonan and Pingdu show relatively high number of pipe-breaks. Further detailed analyses of break-rates for locations, different materials, diameters or time periods laid is recommended to identify common trends in the breaks and to develop a consistent remediation plan. Analysis of this data will allow informed prioritization of future NRW reduction programmes.
4.5 Operating costs, revenues and cost recovery

The table below shows average values for operational costs, staff working per population served and average revenues.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1 Operational Cost (US$/m³ water sold)</td>
<td>0.17</td>
<td>0.18</td>
<td>0.21</td>
</tr>
<tr>
<td>12.3 Staff per 1000 population served (Nr/1000 population served)</td>
<td>1.6</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>18.1 Average Revenue (US$/m³ water sold)</td>
<td>0.18</td>
<td>0.19</td>
<td>0.23</td>
</tr>
</tbody>
</table>

An international comparison of reported operating costs and average unitary revenues is given in figure 10 below.

The reported average operational costs in Shandong Province are low in comparison to other emerging economies at around US$0.17 per cubic meter in 2003 and around US$0.21 per cubic meter in 2005. Such low values suggest that only some operational and maintenance costs are included into the reported cost of the water services. A major cost element that is not adequately reported is debt service. The lowest costs were reported from the medium cities.

In 2005 workforce costs were on average 31% of reported operating costs and electricity costs were on average 25% of reported operating costs. The electricity cost ratio is higher in smaller cities. The staffing ratios of around 0.7-2.0 of staff per ‘000 consumers is double that of developed countries and close to the levels reported from countries of the former Soviet Union. The highest staffing ratios are in small and medium cities where accommodation of new customers requires more labour than in the established larger cities.
Figure 11 below presents the unit operational cost based on water sold.

Figure 11: Unit operational cost based on water sold (partial representation of operational cost)

Figure 12 presents average revenues based on water sold.

Figure 12: Average revenues based on water sold
The Shengliyoutian Water Company of "Victory" Oil LLC has the highest unit costs at around US$0.46 per cubic meter of water sold. This higher cost rate may be attributed to the main customer being able to pay costs closer to the real market cost. In contrast, the lowest rates are found in the county-based water companies.

The water average revenue from water sold is 1.36 RMB/m³ (US$0.17/m³), 1.47 RMB/m³ (US$0.18/m³), and 1.64 RMB/m³ (US$0.21/m³) in 2003, 2004 and 2005, respectively. The water average revenue increased around 10% per year. A breakdown by city size of the trends in the ‘average revenue from water sold’ is given in the table below. Small cities have lower revenue from water sold than medium sized cities which was lower than large cities; this is converse to the logic that larger cities can deliver more efficient services through achieving scale of economies. Mega-cities have a lower average revenue than large cities, suggesting that they have achieved some scale of economy.

<table>
<thead>
<tr>
<th>Average Revenue from Water Sold (US$/m³)</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega-cities</td>
<td>0.17</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>Large cities</td>
<td>0.21</td>
<td>0.22</td>
<td>0.27</td>
</tr>
<tr>
<td>Medium cities</td>
<td>0.17</td>
<td>0.18</td>
<td>0.20</td>
</tr>
<tr>
<td>Small cities</td>
<td>0.09</td>
<td>0.13</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Annual household cost for consuming water 6 m³/month provides an indication of affordability and was found to be 106 RMB (US$13.25), 105 RMB (US$13.13), and 118 RMB (US$14.75) in 2003, 2004 and 2005, respectively. The GNI for China in US$1270 per capita and US$1500 per capita in 2003 and 2004, respectively. Therefore the annual household expenditure on water was 1% and 0.8% in 2003 and 2004, which is considered to be an affordable service and is lower than in many countries with the similar GNI per capita. Conversely, there appears to be adequate room for increasing the price of water and so ensuring a higher cost coverage.

Cost recovery data is summarized in the following table:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.1 Collection Period (Days)</td>
<td>70</td>
<td>72</td>
<td>66</td>
</tr>
<tr>
<td>23.2 Collection Ratio (%)</td>
<td>107</td>
<td>99</td>
<td>98</td>
</tr>
<tr>
<td>24.1 Operating Cost Coverage (ratio)</td>
<td>1.04</td>
<td>1.08</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Average collection periods are reasonable, but as is discussed in the case studies, collection periods for domestic users may be considerably longer, suggesting that these reasonable average collection periods are achieved through early collection of industrial users fees.

Collection ratios are occasionally reported to be above 100%, the water companies have suggested that this discrepancy is caused by revenues not being collected consistently throughout the year, resulting in a short fall one year that is recovered the following year. However, some

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1 Source: World Bank Data Profile Tables 2005  
2 Source: World Bank Data Profile Tables 2006
water companies consistently reported collection ratios over the three year period 2003 to 2005 in excess of 100%, which is clearly due to erroneous reporting while others reported consistently below 100% which may also be erroneous reporting or if correct, suggests that additional effort is required to recover revenues.

As described previously, operating cost data is perceived to only cover some recurring costs through omission of debt service costs. The operating cost coverage ratio as shown in figure 13 is based on the same incomplete data. Around half of the water companies are have sufficient revenue to cover their reported operating costs with the average Operating Cost Coverage being above 1.0, however, if all operating costs are taken into account, then the Operating Cost Coverage is likely to drop below 1.0. The smallest water companies have the lowest Operating Cost Coverage ratios indicating that they have the lowest commercial sustainability and the greatest need for remedial measures and fiscal support.

However in many cases recovery of part of recurring operational costs was achieved by substantial cross-subsidies by non-domestic consumers as shown in figure 14. As was noted above, water revenues are not sufficient to cover the operating costs of small water companies. In contrast, larger water companies achieve cost recovery through price discrimination against industrial consumers. However, smaller water companies are highly dependent on revenues from industrial users and so rarely have opportunity to discriminate against industrial users to generate a higher revenue. The highest cross-subsidy reported the industry based Shengliyoutian Water Company of “Victory” Oil LLC.

![Figure 13: Operating Cost Coverage Ratios (these ratios only represent part of operating costs)](image-url)
Figure 14: Cross-subsidy rates in 2005
4.6 Continuity of Service and Customers with discontinuous supply, water quality and customer complaints

All water companies reported that their water supply service is 24 hours per day. Only Gaomi city reported that there are about 10% customers with discontinuous water supply.

Most water companies reported that the number of tests carried out on samples taken from the distribution system was at least 100% of the number required by the relevant standard. Many companies reported a number of tests well in excess of their regulated obligations. The samples passing the residual chlorine are almost 100% with the average of 99%. However, there is no independent testing information available to validate these results.
5. CASE STUDIES

The following sections provide case studies of two contrasting cities to demonstrate how the Benchmarking toolkit can be used to evaluate performance.

5.1 Case Study of Jinan Water Company

Jinan Water Company is responsible for providing a water service to a population of around 2 million.

The Gross Fixed Water Assets were reported to be 749 RMB/population served, 996 RMB/population served and 474 RMB/population served for 2003, 2004 and 2005, respectively. The Gross Fixed Water Assets compare favourably in comparison to the regional average of 473 RMB/population.

The operating cost coverage ratio was calculated to be 1.61, 2.13 and 1.86 in 2003, 2004 and 2005, respectively. Although initial impression from these high ratios suggests that total annual operational revenues are substantially greater than total annual operating costs, debt service is not adequately reported. High water bills are occasionally used to cover extraordinary capital investments, however there is not a substantial increase in the Gross Fixed Water Assets. Further reporting and study of the financial situation is required to clarify these results.

The debt service to revenue ratio was only 4.2%, 8.7% and 9.1% in 2003, 2004 and 2005, respectively. Although this indicates a healthy balance sheet with sustainable business operations being largely funded from the water company’s own revenues, it is more likely that a substantial portion of capital investment is covered through government subsidy, resulting in the water utilities being vulnerable to parameters outside their control.

The overall collection ratio is reported to be in excess of 100% for all three years surveyed, which the water company explained as being due to collection of overdue revenues. This is an unlikely situation which indicates error in the reporting.

However, the collection ratio from domestic users was found to be poor and requiring immediate remedial action, calculated to be 55%, 69% and 25% in 2003, 2004 and 2005, respectively. A reasonably efficient collection period was found, varying between 61 and 99 days in the period surveyed. Given that overall collection ratios are high, the implication is that industrial users are paying in full and promptly. Therefore, industrial users are not only being charged a higher rate for water, but are bearing a larger responsibility for actually providing revenues.

The annual water bill for a household with a monthly demand of six cubic metres per day was found to be the highest in the province, at 212 RMB/household/annum in 2005, but this is still considered affordable.

The rate at which installed capacity is used was found to be a low 47% for the period surveyed, suggesting investment in supply capacity was well in excess of demand. In contrast, replacement of distribution pipework was found to be unsustainably low at less than 0.8% throughout the period surveyed, but this may reflect that much of the distribution network is recent construction.

Jinan has a very extensive distribution network, extending over 1,400 km. Correspondingly, non-revenue water measured on the basis of the length of distribution network is among the highest in the Province, exceeding 120 m3/km/day or in excess of 30%.

Insufficient information is available to analyze operating costs.

In summary, Jinan Water Company has a very large business to manage. Revenues appear to be substantially larger than required to maintain the business, however reported data is believed to omit costs associated with capital investment, debt service, etc and most likely ignores substantial
government subsidies. Therefore Jinan Water Company may be vulnerable to government subsidy cuts. Improvements in Non Revenue Water would substantially improve the operational efficiency of the business.

5.2 Case Study of Gongying Water Company

Gongying Water Company is responsible for providing a water service to a population of around 0.15 million.

The Gross Fixed Water Assets were reported to be 1846 RMB/population served, 1292 RMB/population served and 892 RMB/population served for 2003, 2004 and 2005, respectively. The Gross Fixed Water Assets compare favorably in comparison to the regional average of 473 RMB/population.

The operating cost coverage ratio was calculated to be 0.77, 0.87 and 0.74 in 2003, 2004 and 2005, respectively. These are low ratios suggesting that total annual operational revenues are substantially lower than total annual operating costs and will not be sustainable in the medium- to long-term. Given that other operating costs such as debt service is not included in these operating cost coverage ratios, Gongying Water Company clearly has difficulty ensuring self-sufficiency in its business.

No data was available on the debt service to revenue ratio.

The overall collection ratio is reported to be exactly 100%, which is considered to be assumed rather than measured data. Moreover, the collection ratio from residential users was found to be poor and highly variable, requiring remedial action, calculated to be 59%, 84% and 48% in 2003, 2004 and 2005, respectively. Excessive collection periods was found, varying between 352 and 512 days in the period surveyed, requiring urgent remedial action. Given that overall collection ratios are high, the implication is that industrial users are paying in full and promptly. Therefore, industrial users are not only being charged a higher rate for water, but are bearing a larger responsibility for actually providing revenues.

The annual water bill for a household with a monthly demand of six cubic metres per day was found to be above the Province average of 118 RMB/household/annum, at 140 RMB/household/annum in 2005, but this is still considered affordable.

The rate at which installed capacity is used was found to be an efficient 80% to 120% for the period surveyed. The 120% suggests that there has been conservative design has resulted in over capacity, but generally utilization suggests that supply capacity is well matched with demand.

Replacement of distribution pipework was found to be very high at between 13% and 35% in the period surveyed, but this may reflect recent construction.

Dongying has a short distribution network of around 150 km. However, non revenue water measured on the basis of the length of distribution network was reported to be variable, ranging from 25 m3/km/day to 113 m3/km/day or between 9% and 30%. There is a corresponding high number of pipe breaks in the distribution network. Causes (such as quality of materials, quality of construction, billing and revenue collection) of this variation should be studied to ensure a stable and high level of revenue recovery.

Operating costs appear to be consistent with the average values throughout the Province.

In summary, Dongying Water Company appears to have urgent need to increase revenues, improve cash flow and to improve efficiency. Opportunities to improve business performance are through improved collection from residential consumers in a shorter collection period and to focus on improving Non Revenue Water.
6. CONCLUSIONS AND FINAL REMARKS

The IBNET indicators survey proved to an important tool for the assessment of the water services in China. In particular the survey provided management with indicators that measure their business performance and provides new tools for monitoring and controlling future business performance. For example the survey highlighted good practice being carried out by the participating utilities and also highlighted areas of business where there is potential scope for efficiency gains.

Urban population density is high, compounded by rapid urban growth. A primary challenge for all the water companies is expanding services to meet the consequent demand. Larger cities have been expanding their network at around 3 to 5% per year. However, this challenge is considerably harder for smaller water companies that are having to expand networks at up to 11% per year, but with considerably less access to fiscal subsidies and less power to ensure adequate revenues to cover expenditures.

Non Revenue Water as a percentage is low, which is attributed to high population densities in the urbanized areas creating a high efficiency and recently installed distribution networks. But actual physical losses (in cubic meters per km) and number of breaks per km of the network are close to the poorer performing countries of the former USSR. Therefore, substantial efficiency gains may be achieved through improvements in operational management of the distribution network such as pressure monitoring and pressure control and through targeted NRW reduction programmes. Specific effort should be put into monitoring and recording incidences of pipe bursts in accordance with location, pipe material, pipe diameter. Analysis of this data will allow informed prioritization of future NRW reduction programmes.

Up to 50% of potable water is consumed by non-residential users. In many places these industrial & commercial users are receiving preferential services from the water companies. However, these industrial & commercial users also cross-subsidize domestic users.

Financial balance of water services is consistent with the underlying premises of the political and economic system of the People’s Republic of China. Social policy dominates in the decision process — tariffs are low, and debts are written off at the end of the year. Small water utilities are in a much worse financial situation than large and medium utilities, as they perhaps have much less political power that their peers in large cities to increase tariffs or impose cross subsidies and rate of cross-subsidization is growing.

An essential step for water companies to ensure self-sufficiency is ensuring transparency of the capital and operational expenditures required to provide a safe and reliable water service. This transparency will assist water companies in quantifying and justifying the necessary increases in water bills to end consumers.

Therefore, financial flows into the sector need to be studied, especially to increase transparency in the provision of funds for system development and network expansion, which are currently provided through municipality sources with limited contribution from the water sectors revenues. In the long-run the financing system of the water services investments and perhaps debt service cannot be considered as sustainable as a substantial proportion of expenditures arise from sources (namely fiscal sources) that are outside of the municipal water sector’s control.

In conclusion, repeating the survey annually and also expanding the survey to more utilities will strengthen the reliability of the database to the benefit of all participating utilities.
References

1. www.ib-net.org
2. IBNET guidance notes
4. World Bank Data Profile Tables 2006
Appendix A Methodology

In accordance with the IBNET data inputs, a questionnaire was designed and agreed by PADECO and SWA in mid May 2006 to collect the operation information from the participating water supply companies. Before distribution to 29 the water companies, a training workshop was conducted on May 16, 2006 to ensure the responsible staff members of the water companies understand the objectives, methodology and quality assurance procedures for completing the questionnaire.

The completed questionnaires by each water company were collected by SWA, and after initial quality review and remedial data collection by SWA, PADECO visited Jinan on July 10, 2006 and discussed with SWA on identified discrepancies of questionnaire inputs and errors. PADECO together with SWA team conducted quality assurance auditing on the completed questionnaires and the EXCEL program of Performance Indicators (PI).

SWA checked and confirmed with each water company to remedy errors and confirm inconsistent data. A cleaned and revised database was provided to PADECO on July 17, 2006. This analysis report is based on the revised database.

Over 40 PIs selected are computed and compared for 29 water companies. The mean value is calculated to present average level of PI, while standard deviation is also provided for each mean value as an indicator on samples’ distribution. For each water company, 3 year change trends (2003, 2004 and 2005) for each PI are also compared to highlight trends in the water companies’ performance.