Beijing Olympic Forest Park

Case Study Brief Prepared by:
Research Fellow: Ming-Han Li, PhD, PLA, PE, Associate Professor, Texas A&M University
Research Fellow: Bruce Dvorak, PLA, Assistant Professor, Texas A&M University
Research Assistant: Yi Luo, PLA, PhD Candidate, Texas A&M University
August 2012

Landscape Performance Benefits and Methods

- *Sequesters an estimated 3,962 metric tons (8,735,000 lbs) of CO2 annually in the trees of the park, equivalent to taking 777 passenger vehicles off the road.*

According to the plant list provided by Beijing Tsinghua Urban Planning & Design Institute, more than 2 million plants were installed in the park, including more than 100 tree species and 80 shrub species. Carbon sequestration in the trees was calculated using the National Tree Benefits Calculator (treebenefits.com, accessed on July 5, 2012 by Yi Luo). Because the calculator has not been extended to areas outside the U.S., Philadelphia was selected for calculation because of its similar altitude and climate condition with Beijing. In the cases that species used were not listed, an average was calculated by the highest value and lowest value among similar species. When similar species were not listed, "Other broadleaf deciduous medium" was used to substitute the deciduous trees.

According to EPA, on average, a passenger vehicle emits approximately 5.1 metric tons of CO_2 per year.

$$3,962 / 5.1 = 777 \text{ vehicles}$$

Sources
Beijing Tsinghua Urban Planning & Design Institute
National Tree Benefit Calculator http://www.treebenefits.com/calculator/
EPA http://www.epa.gov/cleanenergy/energy-resources/refs.html

- *Reduces annual consumption of potable water by 950,000 cubic meters (250 million gallons), the equivalent of 380 Olympic-sized swimming pools, by using reclaimed water from the Qinghe Waste Water Treatment Plant for landscape irrigation and to recharge park water bodies.*

According to Beijing Tsinghua Urban Planning & Design Institute, on average, about 2,600 cubic meters of reclaimed water is discharged from the nearby Qinghe Waste Water Treatment Plant to the park's 10-acre constructed wetland which has a capacity of treating 2,600 cubic meters water per day. The constructed wetland further improves the water quality and discharges to the water system in the park. Water from the constructed wetland is also used for landscape irrigation.

$$2,600 * 365 = 949,000 \text{ m}^3$$

A typical Olympic swimming pool is 50-meter long, 25-meter wide, and 2 meter deep.

$$50 * 25 * 2 = 2,500 \text{ m}^3$$
$$949,000 / 2,500 = 380 \text{ swimming pools}$$

Source
Beijing Tsinghua Urban Planning & Design Institute

- ***Generates 83,000 kWh of electricity per year from solar photovoltaic panels installed on top of the trellis structure at the park's south gate. This is enough to meet the energy needs of 227 China residents for a year and reduce the use of coal by 30 metric tons (66,000 lbs), which in turn reduces the emission of CO2 by 78 metric tons (172,000 lbs), SO2 by 720 kg (1,600 lbs), NOX by 210 kg (460 lbs), smoke by 81 kg (180 lbs), and dust by 45 kg (100 lbs) per year.***

The total area of the solar photovoltaic panels is 950 square meters. The power of the solar panel is 100 watts per one square meter. The average duration of sunlight is 4 hours, and the typical efficiency is about 60%. So for every square meter, the electricity produced per day is:

$$100 \text{ watts} * 60\% * 4 \text{ hours} = 240 \text{ W·h/m}^2$$

The electricity produced by the system per year is:

$$240 \text{ }^{\text{W·h}}/_{\text{m}^2} * 950 \text{ m}^2 * 365 = 83,220,000 \text{ W} \cdot \text{h} = 83,220 \text{ kW} \cdot \text{h}$$

According to the National Bureau of Statistics of China, in 2009, the average electricity consumption per capita in China was 365.9 kWh

$$83,220 \text{ kW} \cdot \text{h} \div 365.9 \text{ kW} \cdot \text{h/person} = 227 \text{ persons}$$

According to the National Development and Reform Commission of China, every 0.36 kg of coal can produce 1 kW·h of electricity. Burning one kilogram of coal can emit 2.6 kg CO_2, 0.024 kg SO_2, and about 0.007 kg NO_X. So the solar photovoltaic panels reduce the use of coal by 30 metric tons, the emission of CO_2 by 77.9 metric tons, SO_2 by 719 kg, and NO_X by 210 kg every year.

Consumption of coal reduced:
$$83,220 \text{ kW} \cdot \text{h} * 0.36 \text{ kg/kW} \cdot \text{h} = 29,959.2 \text{ kg}$$
$$\approx 30 \text{ metric tons of coal}$$

CO_2 emission reduced:
$$2.6 * 29,959.2 = 77,893.92 \text{ kg of } CO_2 \approx 77.9 \text{ metric tons of } CO_2$$

SO_2 emission reduced:
$$0.024 * 29,959.2 = 719.0208 \text{ kg of } SO_2$$

NO_X emission reduced:
$$0.007 * 299,59.2 = 209.7144 \text{ kg of } NO_X$$

According to the National Bureau of Statistics of China, in 2010, the fuel consumption of the whole country was 3,038,970,000 metric tons, the smoke emitted was about 8,291,000 metric tons, and the dust emitted was about 4,487,000 metric tons. Assuming that all the fuel burned was coal, the amount of smoke and dust emitted by one metric ton of coal can be estimated by:

Smoke emitted by one metric ton of coal:
$$8,291,000 \div 3,038,970,000 = 0.0027 \text{ metric ton} = 2.7 \text{ kg of smoke}$$

Dust emitted by one metric ton of coal:
$$4,487,000 \div 3,038,970,000 = 0.0015 \text{ metric ton} = 1.5 \text{ kg of dust}$$

Smoke emission reduced:
$$29.9592 * 2.7 = 80.9 \text{ kg of smoke}$$

Dust emission reduced:
$$29.9592 * 1.5 = 44.9 \text{ kg of dust}$$

Sources
Beijing Tsinghua Urban Planning & Design Institute
National Bureau of Statistics of China
National Development and Reform Commission of China

- ***Significantly improves the quality of life for 96% of the 373 visitors surveyed. Most visitors who were interviewed expressed that the Park is a very nice place to enjoy, providing abundant recreation and exercise opportunities.***

Visitors of the park were randomly selected for taking a survey of users' preferences on July 7, 2012, July 9, 2012, and July 11, 2012. A total of 373 responses were received. For the question "The Beijing Olympic Forest Park has largely improved the life quality of me and my family," 140 and 218 of the respondents answered "strongly agree" and "agree," respectively, which accounts for approximately 96% of the respondents.

$$(140 + 218) \div 373 * 100\% = 96\%$$

Source
Beijing Tsinghua Urban Planning & Design Institute

- ***Provided an outdoor classroom for about 2,000 children from elementary schools within 2 km of the Park in 2011.***

Principals of 8 elementary schools within 2 km of the Olympic Forest Park were telephone interviewed. The results indicate that most schools have field trips to the park every year. The total number of students attending the field trips to the park in 2011 is about 2,000.

Source
Beijing Tsinghua Urban Planning & Design Institute

- ***Created 1,563 new jobs in the park, including landscaping, security, and cleaning services.***

According to Beijing Tsinghua Urban Planning & Design Institute, 1,563 new jobs have been created in the park, including 830 landscaping positions, 320 security guarding positions, and 413 cleaning positions.

Source
Beijing Tsinghua Urban Planning & Design Institute

Cost Comparison Methods

- ***Located in northern China, Beijing is relatively dry, and it is necessary to regularly recharge the water body in the park. Using reclaimed water instead of potable water saves an estimated $448,000 annually.***

Every year about 949,000 cubic meters of reclaimed water is imported to recharge the water body and irrigate the landscape in the park. The price for reclaimed water in Beijing is $0.1573/$m^3$, and the price for potable water is $0.6292/$m^3$. Therefore, the cost saved is about:

$$(0.6292 - 0.1573) \times 949,000 = \$447,833 \text{ per year}$$

Source
Beijing Water Authority http://www.bjwater.gov.cn/tabid/110/Default.aspx

- ***The solar photovoltaic panels generate 83,000 KWh every year to power part of the park, which saves about $6,400 annually in electricity costs.***

The price for electricity in Beijing is $0.0766/kW·h., so the annual cost saving is about:
$$0.0766 * 83,220 = \$6,375 \text{ per year}$$
Source
BJZD, http://www.beijingzidian.com/xinwen/2011/0524/89.html