Renewable and Sustainable Energy Reviews 64 (2016) 660–671

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Effect of the tap water supply system on China's economy and energy consumption, and its emissions' impact

Xiaohong Zhang [a,*], Yan Qi [a], Yanqing Wang [a], Jun Wu [a], Lili Lin [b], Hong Peng [a], Hui Qi [a], Xiaoyu Yu [a], Yanzong Zhang [c]

[a] Department of Environment Science, College of Environmental Sciences, Sichuan Agricultural University-Chengdu Campus, Chengdu, Sichuan 611130, PR China
[b] Department of Environmental Engineering, College of Environmental Sciences, Sichuan Agricultural University-Chengdu Campus, Chengdu, Sichuan 611130, PR China
[c] Department of Environmental and Ecological Engineering, College of Environmental Sciences, Sichuan Agricultural University-Chengdu Campus, Chengdu, Sichuan 611130, PR China

ARTICLE INFO

Article history:
Received 13 August 2015
Received in revised form
23 February 2016
Accepted 26 June 2016
Available online 14 July 2016

Keywords:
China's tap water supply
Economic development
Energy consumption
Pollutants discharge

ABSTRACT

Water supply systems have led to the related effects on goals of nation energy consumption, environmental protection and economic development due to their energy use, pollutants discharge and economic cost. This work put forward a set of indicator system and the related methods, based on energy, current, mass and emergy, to describe the complicated interactions between water supply systems, economic development, energy consumption and environmental impact. As a case, the proposed indicators and methods were used to explore the effects of China's tap water supply system (TWSS) on national economy, energy and environment from 2000 to 2013, so as to discover some underlying obstacles hindering the sustainable development of China's TWSS. The study results show that (1) per capita water use declines by 28.11% from 102.17 t/person in 2000 to 73.45 t/person in 2013; (2) the contribution of China's TWSS to national economy and energy decreases by annual decline rates of 5.37% and 3.66% respectively; (3) the total pollution discharge from this system ascends by an annual growth rate of 1.06%, of which 97.44% comes from sludge discharge in terms of mass; therein, the contribution of COD discharge from this system to national COD discharge rises by an annual growth rate of 2.57% while the contribution of sludge discharge from this system to national sludge discharge falls by an annual decrease rate of 9.26%; generally the environmental impact intensity of this system ascends by an annual growth rate of 0.17%; (4) the annual average leakage rate of 16.49% leads to a lot of water waste. Therefore, China's government will still face the two serious challenges derived from the rising water demand and the increasing energy consumption from tap water supply with development of its society and economy. After discussing the related issues, this work gives the corresponding policy suggestions.

Contents

* Corresponding author.
E-mail address: zxh19701102@126.com (X. Zhang).

http://dx.doi.org/10.1016/j.rser.2016.06.067
1364-0321/

1. Introduction

Water is vital for the life and health of people and ecosystems, and it is also a basic requirement for economic development [1]. A large amount of energy is consumed for transmitting lots of qualified water to human society from nature during the course of water transportation, treatment and distribution. E.G., the world energy consumption for water distribution is about 7% of the global energy [2]. Therefore, there exist close relationships between water and energy, which are two of essential elements for the well-being of the societies.

As one country with the largest population in the world, China has a very limited per capita water capability. As shown in Fig. 1, total amount of water resource of China slowly rose along a fluctuation way from 2000 to 2013, with an average value of 2.69E12 m^3 per year; per capita water resource of the country slowly declined in this study period, with an average value of 2.05E03 m^3 per capita. Although the total of water resource in China is large, the per capita water resource is only one quarter of the world's average level [4]. Meanwhile, due to uneven spatial and temporal water resource distributions [5], more than half of the 667 cities in China are facing water shortage [6]. Meanwhile, poor water quality caused by pollution further exacerbates the lack of water availability in water-scarce areas [7]. Water shortages and poor water quality are interacting with each other and threatening the capacity of water systems to sustain China's socio-economic development [8]. The constraint of water resource on China's future development is of great concern, both domestically and internationally, and is considered a grand challenge that the Chinese government has to address in the future [7,9].

The fast growing economy is also driving the rising water supply in recent years. As illustrated in Fig. 2, China's water supply increased from 5.53E11 m^3 in 2000 to 6.18E11m^3 in 2013, with an annual growth rate of 0.86% in this period. China's Gross Domestic Product (GDP) rose by 10.02% in the same period (according to the constant price of 1978) [3]. The huge need for water supply derived from fast economic growth and urbanization with a large and growing population has affected the sustainable development of China's social economy, especially north China. In order to alleviate the increasing water crisis in those areas, the South-to-North Water Diversion Project, one of the largest water projects in the world, seeks to promote the economic growth of Northwest China and Northern China by relaxing water constraints [10]. However, the ecological environment related issues have been and will be widely concerned.

As shown in Fig. 3, China's water use rose by 12.47% from 5.5E11 m^3 to 6.18E11 m^3 from 2000 to 2013, with an annual growth rate of 0.91% in this period. On the average, 64.06% of water use came from agriculture, 22.66% of water use came from industry, 11.91% of water use came from household, and 1.36% of water use came from ecology during the same period.

Therefore, energy, water, environment and economy are inseparable issues, even though their policies are often drafted separately [11–16]. In recent years, the growing demand of energy and water resources and the increasingly serious environmental challenges (including local environmental pollution and global environmental problems) have push forward discussions and studies on the water-energy nexus [17–32], the interactions between water supply, population and economy [33], the relationships between water supply, energy and environment [34], the relationships between water supply, economy, energy and environment [35,36], relationships between water supply and environment [37], life cycle assessment of water supply scenarios [38,39], the relationships between water supply and economy [40]. In addition, some scholars have carried out the related researches to improve comprehensive performance of water supply systems, including water supply availability and energy efficiency [41,42], energy consumption and energy efficiency [43,44], effects of different purification technologies on treatment efficiency [45], the interactions between technological developments and new energy sources [46], The co-benefits between water and energy saving actions [47], water and energy efficiencies [48], etc. However, few works have considered the effects of China's water supply system

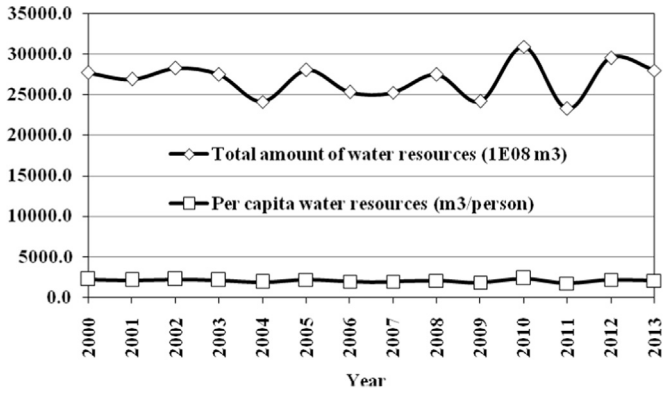

Fig. 1. Trends of China's amount of water resource and per capita water resource from 2000 to 2013 [3].

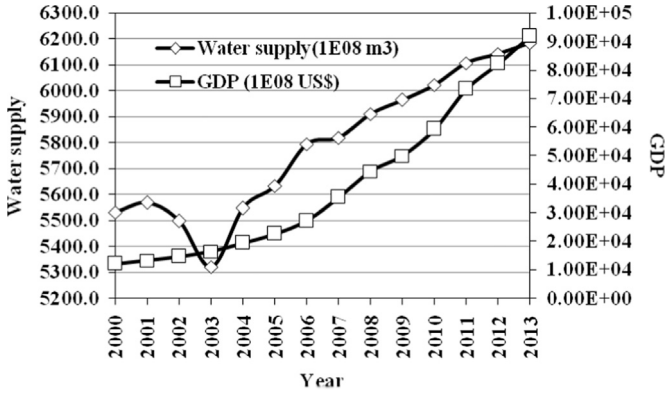

Fig. 2. Trends of China's water supply and its GDP from 2000 to 2013 [3].