Energy Policy 65 (2014) 332–339

Contents lists available at ScienceDirect

Energy Policy

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

Effects of urbanisation on energy consumption in China

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HIGHLIGHTS

- Urbanisation slows per capita REC growth when compared with rural areas.
- Urbanisation has a greater promotional effect on REC growth and a stronger improved effect on energy structure than do rural areas.
- The economic growth effect of urbanisation is responsible for the majority of PEC growth.
- Technological advancement in conjunction with urbanisation has an adverse effect on the increase in PEC.
- The structural effect of the energy supply on the urbanisation process has increased rather than decreased China's PEC.
- There is no significant evidence that industrial structure adjustment in the urbanisation process affects PEC.

ARTICLE INFO

Article history:
Received 9 July 2013
Received in revised form
24 September 2013
Accepted 1 October 2013
Available online 5 November 2013

Keywords:
Energy consumption
Effects of urbanisation
China

ABSTRACT

As a key issue in China's economic development, urbanisation creates increasing pressure on energy supply and the natural environment. Thus, a better understanding of the relationship between urbanisation and energy consumption is necessary for Chinese decision makers at various levels to address energy security and sustainable economic and social development. This paper empirically investigates the effects of China's urbanisation on residential energy consumption (REC) and production energy consumption (PEC) through a time-series analysis. The results show that compared with rural areas, urbanisation slows per capita REC growth because of the economy of scale and technological advantages associated with urbanisation but has greater promotional effects on the growth of REC and the improvement of REC structure. The economic growth caused by urbanisation most significantly contributes to an increase in PEC, whereas technological advancement was found to reduce the scale of PEC (except from 2001 to 2005). Finally, the structural effect of the energy supply increased rather than decreased China's PEC, and the effect of industrial structure adjustment on PEC was found to be insignificant.

1. Introduction

With the implementation of its 'Reform and Opening-up' policy in 1978, China entered a period of rapid urbanisation. The rate of urbanisation increased from 19.39% to 51.27% between 1980 and 2011. Although China has made remarkable developmental progress, much of the country has yet to be urbanised, particularly in western and central China. Millions of people from rural areas add to the populations of cities and towns across China every year. This migration creates increasing pressure on the country's urban development and urban energy supply. Urbanisation can promote economic growth and improved living standards, but it can also increase energy consumption (Al-mulali et al. 2012; Liu 2009a,b) and, in turn, produce energy crises. Since the early 1990s, there has been a tremendous increase in energy demand spurred by industrial development and population growth, resulting in a greater thirst for the world's energy supply as the national supply–demand gap becomes wider. As a result, China's dependence on foreign energy supplies is growing; the demand for oil increased 59.18% in 2010, when crude oil production and importation reached 203.01 and 294.37 million tons coal equivalent (Mtce), respectively. It is estimated that China's dependence on foreign oil will soar to 60% by 2020 (Cui, Huo, 2009). Such a high degree of dependence poses a tremendous energy challenge with regard to the growing urban energy demand. Therefore, the relationship between energy consumption and supply is a key issue in terms of sustainable urbanisation in the country.

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http://dx.doi.org/10.1016/j.enpol.2013.10.005

Table 1
Urbanization and energy consumption in China from 1980 to 2011.

Year	1980	1981	1982	1983	1984	1985	1986	1987
Urbanization (%)	19.39	20.16	21.13	21.62	23.01	23.71	24.52	25.32
Energy consumption (Mtce)	602.75	594.47	620.67	660.40	709.04	766.82	808.50	866.32
Year	1988	1989	1990	1991	1992	1993	1994	1995
Urbanization (%)	25.81	26.21	26.41	26.94	27.46	27.99	28.51	29.04
Energy consumption (Mtce)	929.97	969.34	987.03	1,037.83	1,091.70	1,159.93	1,227.37	1,311.76
Year	1996	1997	1998	1999	2000	2001	2002	2003
Urbanization (%)	30.48	31.91	33.35	34.78	36.22	37.66	39.09	40.53
Energy consumption (Mtce)	1,351.92	1,359.09	1,361.84	1,405.69	1,455.31	1,504.06	1,594.31	1,837.92
Year	2004	2005	2006	2007	2008	2009	2010	2011
Urbanization (%)	41.76	42.99	44.34	45.89	46.99	48.34	49.95	51.27
Energy consumption (Mtce)	2,134.56	2,359.97	2,586.76	2,805.08	2,914.48	3,066.47	3,249.39	3,480.02

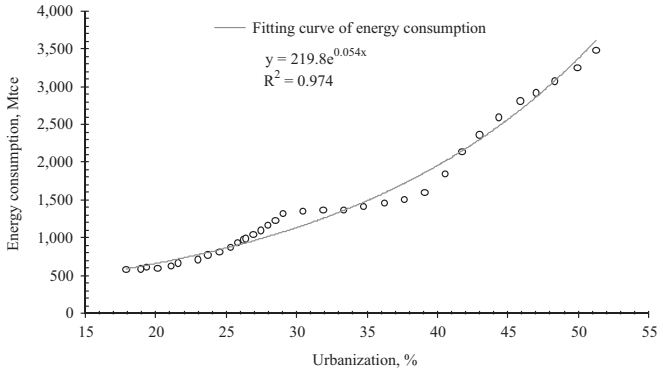

Fig. 1. The changing pattern of urbanization and energy consumption in China from 1980 to 2011.

As shown in Table 1, the urbanisation rate in 1980 was 19.39%. The average annual increase in the urbanisation rate between 1980 and 1995 was 0.64%. Rapid urbanisation began in the mid-1990s. The urbanisation rate increased from 30.48% to 51.27% between 1996 and 2011, rising approximately 1.39% annually. Urbanisation accelerated social energy consumption in the same period. Total energy consumption jumped from 602.75 Mtce in 1980 to 3480.02 Mtce in 2011. The fitting curve in Fig. 1 shows the exponential relationship between urbanisation (the independent variable) and energy consumption (the dependent variable) during the period 1980–2011.

Growing energy consumption in conjunction with the urbanisation process poses a practical challenge for energy economics (Adams and Shachmurove 2008). There is an urgent need to study the relationship between urbanisation and energy consumption to inform the long-term energy policies developed by Chinese governments. Accordingly, the purpose of this study is to show the overall impact that urbanisation has on energy consumption, including the urban contributions to China's residential energy consumption (REC) and production energy consumption (PEC). The study provides a reasonable rationale and new empirical evidence for the internal dynamics of urbanisation in relation to energy consumption over the period 1980–2011.

2. Review of the literature

Because of the growing concern over environmental impacts and the increase in energy crises caused by urbanisation, many researchers have investigated the connection between urbanisation and energy consumption from various perspectives, and four research strands have emerged.

The first strand of research focusses on the correlation between energy consumption and urbanisation. There is an extensive body of literature examining the positive correlation between energy demand and urbanisation. Jones (1989, 1991) conducted an aggregate cross-sectional regression analysis of 59 developing countries and verified that urbanisation on its own is a significant source of increased consumption. Dahl and Erdogan (1994) briefly discussed the level of urbanisation and industrialisation when explaining energy demand in developing countries. Parikh and Shukla (1995) developed a fixed-effects model to quantitatively assess the impact of urbanisation on energy consumption. Imai (1997) conducted an empirical analysis using Chinese data to argue that urbanisation has caused an increase in energy consumption per capita. Zhou et al. (2012) investigated the effects of the urbanisation process on Chinese energy consumption patterns. Their study identified and analysed three energy-consuming sectors associated with urbanisation: residential households, transportation and the building materials industry. However, a strongly negative correlation between energy consumption and urbanisation exists in many regions, as documented in the well-known studies by Kenworthy and Laube (1996) and Ewing and Rong (2008). Lariviere and Lafrance (1999) found, in Canada, that more urbanised areas had lower per capita energy consumption.

The second strand of research focusses on the causal relationship between energy consumption and urbanisation. Shahbaz and Lean (2012) found that urbanisation had a long-term and short-term causal relationship with energy consumption in Tunisia. Liu (2009a,b) also found that urbanisation had a long-term and positive causal relationship with energy consumption in China. Fan and Xia (2011) obtained similar results for China. Mishra et al. (2009) tested for Granger causality and provided long-term structural estimates of the relationship between energy consumption and urbanisation, revealing the existence of a short-term Granger causality between urbanisation and energy consumption. Halicioglu (2007) used the autoregressive distributed lag (ARDL) method to test for Granger causality between energy consumption and energy prices, gross domestic product (GDP) and urbanisation in a single-country study of Turkey over the period 1968–2005. Halicioglu found that Granger causality runs from GDP, prices and urbanisation to energy consumption over the long term, but the results were inconclusive over the short term.

The third strand of research focusses on urban energy metabolism by analysing a specific city system from an energy point of view. Odum and Peterson (1972) linked the complexity of cities to energy flows. Population-level energy requirements and the energy characteristics of cities based on fossil fuels were also examined by Odum and Odum (1981). Chen et al. (2011) attempted to empirically estimate the relationships between urban land-use patterns and energy consumption in five cities of