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Working Paper 53
http://ceep.bit.edu.cn/english/publications/wp/index.htm

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June 2012

This paper can be cited as: *Liao H, Du J, Wei Y-M. 2012. Energy conservation in China: Key provincial sectors at two-digit level. CEEP-BIT Working Paper.*

This study is supported by the "Strategic Priority Research Program" of the Chinese Academy of Sciences (XDA05150600), National Natural Science Foundation of China (71020107026, 71273027), and Beijing Planning Office of Philosophy and Social Science (11JGC105), National Basic Research Program of China under the Grant No. 2012CB955704. Hua Liao is also grateful to Mr. Xiaorong Liao for his hard and careful data collecting, and Ms. Xiancheng Lu for her excellent language assistance. The views expressed in this paper are solely authors' own and do not necessarily reflect the views of the supporting agencies. The authors alone are responsible for any remaining deficiencies.

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Energy conservation in China: Key provincial sectors at two-digit level

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Abstract: In March 2011, China's central government set a new challenging target of reducing its energy intensity by 16% during 2011-2015, after it had achieved a reduction of 19.1% during 2006-2010. And this new target was assigned to provincial authorities in August 2011. However, China's provincial energy-economic developments are unbalanced and different provinces have different key sectors for energy conservation. Most previous studies focused on provincial energy efficiency at the aggregate level, or the three-industry level (or one-digit level). However, whether for policy decision or academic research, it is necessary to further subdivide the sectors. In this paper, we use three indicators (Gini Coefficient, energy consumption share and energy intensity) to compare provincial energy conservation potentials at the two-digit sector level. To our knowledge, this paper is the first one to identify the keys for energy conversation across the 31 provinces × 65 sectors. And the results are shown in visualized maps and matrix tables to help identify the key province×sectors for energy conservation easier. This also helps the central and provincial governments to distinguish key sectors when they monitor the energy conservation progress.
Keywords: Energy Conservation; China; Two-digit level

1. Introduction

During the 11th Five-Year Plan Period (2006-2010), China made great efforts on energy conservation and achieved a lot with some economic cost. According to the official communiqué [1], China's energy intensity (in terms of energy consumption per unit of GDP) in 2010 dropped by 19.1% compared to that in 2005. In order to further improve its energy efficiency and address the climate change, China's 12th Five-Year Plan again set an ambitious challenging target of reducing its energy intensity by 16% [2]. And it assigned this target to local provinces that are required to reduce their provincial energy intensity by 10-16% (see Fig.1). The quantitative assignments across provinces are different according to their local economic development levels and the informal negotiations among the central and provincial governments.

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However, China's provincial developments are much unbalanced. Both the resource endowments and the social-economic development levels are much different across provinces. For example, the GDP per capital of Ningxia Province (P30) is only equivalent to one third of that of Beijing, while its energy intensity is more than five times of that of Beijing (See Fig.2.). The industrial structures are also quite different among them. The marginal energy conservation costs by province and by sector are quite distinct from each other. Different provinces have different key sectors for energy conservation and vice versa. Furthermore, some provincial energy consumptions are so high that they are equivalent to many large countries. For example, the energy consumption in Shandong province is equals to that of Korea, ranking Top 10 in the world. When investigating a country's energy intensity, it usually discusses the disaggregate data by sector. Since China's provincial energy consumptions are very large, there is no reason to only study provincial energy intensity at the aggregate level. It is necessary to further subdivide the provincial sector (e.g. at two-digit sector level) and investigate their energy efficiency in detail. For these reasons above, it is important to further identify the key sectors for each province (or the key provinces for each sector). How to identify the keys? For a province, those sectors with high energy intensities but low energy consumption volumes are not the key sectors of this province. Therefore, both the energy consumption volume and intensity are required to be jointly considered when we try to identify the key sectors for each province. It is also suggested that every province not only consider their own conditions but also analyze its differences compared to other provinces when we select key sectors for energy conservation.

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By employing Gini Coefficient and energy consumption share analysis, we do comparison analysis of provincial energy conservation potentials at two-digit sector level. To our knowledge, this paper is the first one to classify the 31 provinces × 65 sectors according to their energy conservation potential, and most previous researches across provinces only focused on energy conservation at the aggregate level [3-6], industrial aggregate level [7], or three-industry level (still one-digit level) [8]. Some literature investigated the China's energy conservation by sector [9-10], but they did not analysis them at the provincial level. Our results are shown in visualized maps and matrix tables to help identify the key province×sector for energy conservation easier. This also helps the central and provincial governments to distinguish key sectors when they monitor the energy conservation progress.

2. Data descriptions

For the convenience of writing and expressing, Sector i of Province j is set to be (i, j), The economic activity is divided into 65 sectors. And there are 31 provinces in Mainland China. c_{ij} is the energy consumption of (i, j), y_{ij} is the gross output value of (i, j), and e_{ij} is the energy intensity of

(i, j). Therefore, $e_{ij} = c_{ij} / y_{ij}$. $C_j = \sum_{i=1}^{65} c_{ij}$, and it refers to the aggregate energy consumption of Province j. $N_i = \sum_{j=1}^{31} c_{ij}$, and it refers to all provincial energy consumption of Sector i. Si ($i = 1, \cdots, 65$) is the sector code of the i th sector, and Pj ($j = 1, \cdots, 31$) is the province code of the j th province. The codes and full names of province are listed in a map (see Fig.3). And the codes and names of sectors are listed in Table 1. For example, P6 represents Liaoning Province, S22 represents Sector of Manufacture of Medicines and $(22, 6)$ represents S22 of P6.

<Table 1 is inserted around here.>

There are much troublesome issues with China's provincial economic and energy data:

Firstly, the provincial regular energy statistical data are notorious for its inaccuracy and unreliability. We take provincial energy consumption data as an example: there are mainly 4 possible official sources: (1) *China Energy Statistical Yearbook (CESY)*; (2) The provincial *Energy Balance Tables*; (3) *Energy Conservation Communiqué*; (4) *Provincial Statistical Yearbooks*. However, there is much difference and conflict among these four sources though all of them are published officially.

Secondly, almost all the regular statistical yearbooks do not include sectoral energy data at two-digit level. For example, the industrial energy consumption data by province are reported aggregately in *CESY*, regardless of the sub-sectors. Industrial energy consumption accounts for 70% of total energy consumption, but the data unavailability adds the difficulty to further study it at a more disaggregate level.

Thirdly, the regular statistical coverage of the economic (e.g. industrial gross output) and energy consumption data are quite distinct. For example, the national industrial outputs at two-digit level which are reported in regular statistical yearbooks only cover industrial enterprises above designated size (revenue from principal business over RMB 5 million), while the national energy data cover all industrial enterprises [11]. This is also inconvenient for energy-economic analysis and decision-making.

Fortunately, in 2008 China's Second National Economic Census (SNEC) attached more importance on energy data quality. And the Second National Economic Census Office [12] released the census data of energy by province and by sector (i.e. c_{ij}) at two-digit level, which are highly reliable compared to that from regular statistics. These industrial energy data subdivided into 43 sectors $\times$31 provinces $\times$22 energy types is so far the most detailed in China. Based on the census data at two-digit level, this paper compares the energy consumption c_{ij} and intensity e_{ij} by sector and by province ($i = 1, \cdots, 65$, $j = 1, \cdots, 31$). The methodologies are slightly different from each other when indentify the keys in agriculture, industry and the tertiary industry. For the agriculture sector, we classify the provinces into two categories (*key* and *non-key*) according to their electricity and diesel consumption respectively. For the industrial sector, since it consumes about 70% of China's energy, we classify the provinces into three categories (the *most-key*, *key* and *non-key*). For the tertiary industry, we classify the provinces into two categories (the *key* and *non-key*) based on their economic activities.

We label the categories in matrix tables or maps to make it easy to indentify the key (i, j) which have large energy conversation potential in China's 12th Five Year Plan Period. Industrial sectors (S2-S40) and tertiary industries (S42-63) account for near 90% of China's energy consumption, and they are the most important sectors for energy conservation. Therefore, we will intensively investigate S2-S40 and S42-63, and briefly analysis the agriculture (S1), construction industry (S41) and residential sectors (S64 and S65).

3. Key province for energy conservation in agriculture sector (S1)

The value added in agriculture takes up around 10% of China's GDP, and the energy share is much smaller (1.5%). The mainly commercial energy types in agriculture are electricity for irrigation and diesel for planting and harvest. In the process of mechanization and automatic irrigation, diesel and electricity consumption increases slowly. Therefore, the provinces with large electricity and diesel consumption which are usually China's main grain producing areas are the keys for energy conservation as shown in Fig.4. The planting structure is highly restricted by many factors such as the local climate and water resource conditions, etc., that means it is impossible to be substantially changed for the purpose of energy conservation. Therefore, improving efficiency on machinery and irrigation equipment is suggested for main alternatives for energy conservation in agriculture.

<Fig.4 is inserted around here.>

4. Key (i, j) for energy conservation in industrial sectors (S2-S40)

For China's most provinces, industrial energy conservation plays a pivotal role in the provincial energy intensity reduction, since industry takes up 70% of the total energy consumption. In addition, the industrial enterprises above designated size (revenue from principal business over RMB 5 million) which account for over 65% of China's energy consumption and 90% of industrial energy consumption deserve particular attention. Fig.5 presents the details by province.

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Investigating the aggregate energy consumption or intensity by province at one-digit level is valueless because there is much difference among the provincial manufacturing processes. But at two-digit level there is much comparability across the provinces. Therefore we investigate the c_{ij} and e_{ij} by province and by sector at two-digit level. Here we use the gross output value y_{ij} of (i, j) and calculate the energy intensity e_{ij}. There are 39 industrial sectors at two-digit level and their energy intensities can be calculated by province. We introduce Gini Coefficient G_i which is widely used in income inequality to measure the provincial energy intensity difference of Sector i:

$$G_i = \frac{\sum_{j=1}^{31} \sum_{k=1}^{31} w_{ij} w_{ik} \left| e_{ij} - e_{ik} \right|}{2 \overline{e_i}} \qquad \text{Eq. (1)}$$

This calculating formula is derived by Dorfman [14], Kendall and Stuart [15]. e_{ij} represents the energy intensity of (i, j), The weights w_{ij} represents the energy consumption share of Province j in Sector i, i.e. $w_{ij} = c_{ij} \Big/ \sum_{j=1}^{31} c_{ij}$ (c_{ij} represents the energy consumption of (i, j) as mentioned in Section 2). $\overline{e_i} = \sum_{j=1}^{31} c_{ij} \Big/ \sum_{j=1}^{31} y_{ij}$, and it represents the energy intensity of Sector i of China.

The Gini indices by industrial sector are reported in Table 2. For a sector with larger Gini Coefficient, it means that there is more energy intensity difference across provinces and those provinces with higher energy intensities has more potential for energy intensity reduction. For example, the Gini Coefficient of Sector 27 (Smelting and Pressing of Ferrous Metals) is 0.44 and that of Sector 3 (Extraction of Petroleum and Natural Gas) is only 0.33. This means Sector 27 has much more significant provincial energy intensity difference than that of Sector 3. For a specific sector with higher Gini Coefficient (usually $G_i > 0.4$), provinces with lower energy intensity provide good benchmarks for those with higher energy intensity.

<Table 2 is inserted around here.>

For each sector, based on the Gini Coefficient, energy consumption scale and energy intensity ranks, we classify the provinces into three categories for energy conservation: the *most-key*, *key* and *non-key*. Here are the categorizing steps:

(1) Identify the sectors with large energy consumption. Sector i with total provincial energy consumption $\sum_{j=1}^{31} c_{ij}$ over 20 Mtce is marked for energy conservation. There are 15 large energy consumption sectors and their consumption summation accounts for over 90% of China's industrial energy consumption.

(2) Identify the key provinces in the 15 sectors (i.e. the *key* (i, j)) and label them ★. Due to the difference of natural endowments, historical accumulation and market structure across provinces, not all provinces are the key ones for each of the 15 sectors. For example, $(28,3)$ (Sector of Smelting and Pressing of Non-ferrous Metals, Hebei Province) consumes little energy. So we only retain the key provinces in the 15 sectors and discard the non-key ones. For each of the 15 sectors, we rank the 31 provinces according to their energy consumption in descending order and calculate their accumulated energy consumption cumulatively. Then in Sector i, those provinces in top x% are identified as the key (i, j) for energy conservation. Here the value of x% is usually 75%-95%, and the specific value is depended on the characters of Sector i such as Gini Coefficient, energy intensity and consumption scale. For example, the key provinces for energy conservation cover top 95% of the accumulated energy consumption in Sector 28 (Smelting and Pressing of Non-ferrous Metals). The results of x% and *key* (i, j) are shown in Table 2.

(3) Identify the *most-key* (i, j) (labeled in ★ with gray color filled) from the above *key* (i, j). We defined *key* (i, j) with $e_{ij} > 0.7\overline{e}_j$ as the *most-key* (i, j). The results are shown in Table 2.

According to Table 2, it is easy to find which (i, j) is the *key* or *most-key* province×sector for energy conservation. For example, Fujian Province has one *most-key* sector (S38: Production and Supply of Electric Power and Heat Power) and three *key* sectors (S17: Manufacture of Paper and Paper Products; S26: Manufacture of Non-metallic Mineral Products; S27: Smelting and Pressing of Ferrous Metals). Hainan province has no key (i, j) since its industrial output only accounts for a small share of GDP. S29 (Manufacture of Metal Products Sector) has 9 *most-key* provinces (Tianjin, Hebei, Jiangsu, Zhejiang, Shandong, Henan, Hunan, Sichuan, Guizhou) and 4 *key* provinces (Liaoning, Shanghai, Hubei, Guangdong).

Simple and direct results are shown in Table 2 and some implications can be derived from it. For example, Beijing should attach importance to S20 (Petroleum Processing Sector), since S20 is the most-key sector in Beijing. There are many key/most-key sectors in Hebei, Liaoning, Jiangsu, Zhejiang, Shandong, Henan, Guangdong and Sichuan. Some provinces with high aggregate energy intensities only have a few key sectors. Taking Ningxia Province as an illustration, China's public opinion usually argue that Ningxia should make the most of efforts for energy conservation because its highest energy intensity. But the results in Table 2 show that Ningxia has only one most-key sector (S21: Manufacture of Raw Chemical Materials and Chemical Products) and one key sector (S28: Smelting and Pressing of Non-ferrous Metals) for energy conservation. This is because the energy consumption volume is very small. Therefore, by turning to Table 2, we can easily find which province×sectors have the great energy conservation potential.

5. Energy consumption in construction industry (S41)

Construction industry (the constructing process of buildings) itself is not the key sector for energy conservation for it only takes up 1.3% of national energy consumption. Someone may argue this viewpoint. According to China's current statistical data coverage, the energy consumption in buildings such as heating /air-condition/ cooking systems classified into that of residential sector. Here the construction industrial energy consumption only refers to that directly used in the constructing process. This figure is very small in China. Construction industry is not the key sectors for energy conservation in China, but the building standards and regulations are important since they will have impacts the heat insulation functions.

6. Key (i, j) for energy conservation in the tertiary industry (S42-S63)

The key sectors, accounting for over 80% of all the tertiary industrial energy consumption, include mainly Transportation (S42-S47), Wholesale and Retail Trade (S51), Accommodation and Restaurants (S52), Real Estate (S55), Education (S60), and Public Management and Social Organization (S63). They are identified based on their economic activity and energy consumption volume (see Table 3). There are some special points: Firstly, according to China's administrative system, in addition to the local provinces, some ministry departments are also responsible for the energy conservation. Ministry of Railway (A1) administrates railway transport (S42) and the Ministry of Transport (A3) administrates road, water and air transport (S43, S45, S46). And the Ministry of Industry and Information (A2) is in charge of the equipment manufacturing that determines the energy efficiency of transport equipment. Secondly, we put the urban public traffic sector (S44)'s energy conservation responsibility to the local cities because it is mainly regulated by the local municipalities not the Ministry of Transportation. Thirdly, for S62 (Culture, Sports and Entertainment Sector), the 31 provincial capitals and 5 special municipalities (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen) are the keys for energy conservation since most of these sector activities are centered on the large cities.

<Table 3 is inserted around here.>

The value added of tertiary industry in Beijing accounts for 76% of its GDP [16]. As shown in Table 4, Public Transportation Sector (S44) in Beijing in 2008 consumed 1462 ktce of energy, equivalent to 83 kce per capita. The Public Management Sector (S63) consumed over 910 ktce of energy, among which gasoline and diesel taking up 210 ktce, equivalent to 390 kce per capita. The electricity consumption per employee in S63 was 3430 kwh, five times of electricity consumption per capita in the residential sector. Therefore, there are possible much energy wasting in the public sectors and much closer attention should be given to S44 and S63 when the governments make energy conservation work plans.

<Table 4 is inserted around here.>

7. Rural and urban residential energy consumption (S64 and S65)

With the improvement of urban and rural residential income levels, there is a trend of continuously increasing energy consumption in residential sector [18]. In the urban, private vehicles consumption contributes most to this increase and is growing along with the economic development. For example, gasoline consumption on private transportation in Beijing was 130 kg per person (excluding taxi and other vehicle involved in business) in 2009, 40 to 60 times of that in underdeveloped provinces like Sichuan, Henan and Gansu. Further more, the gasoline consumption growth rate is much higher (2.31 times) than that of the residential income, as Fig.6 illustrates that the elasticity of gasoline consumption to residential income is 2.31. China's urbanization rate is just over 50% and will continue to increase, so more and more urban resident will owe private vehicles. It is important and urgent to discourage private car using, develop public transportation dramatically and guide residential energy saving behavior on transport.

<Fig.6 is inserted around here.>

In the rural, household electrical appliances contributes to most of the commercial energy consumption. Although household electrical appliance (such as air-condition, refrigerator, heating facility, etc.) ownerships in the urban are close to saturation, there is a large demand potential in the undeveloped rural area. As shown in Fig.7, all the scatters are above on the 45° line. It means for any province, air-condition ownerships in the urban are much more than that in the rural. And there is much electricity consumption and household electrical appliance inequality across provinces. For example, the average of air-conditions ownership in rural Zhejiang is 85 units per 100 households, while this figure is no more than 1 in many provinces. So there is a large space for household electrical appliance growth. With the rural development and its urbanization, more and more household will be equipped by various appliances. This may result in much energy consumption growth. Therefore, it is urgent to introduce the more energy-efficient appliance to the rural.

<Fig.7 is inserted around here.>

8. Conclusions

Due to the information asymmetry and imperfect market mechanism, there is no doubt that both the central and local government will take administrative measures to realize its ambitious energy conservation goal in the next years. For example, enhancing technology transformation, upgrading in traditional industries, shutting down small thermal power generating units all will to be done [22]. Therefore, it is vital to indentify where the key or most-key fields for energy conservation are, or where lowest marginal energy conservation costs are. While most conventional studies focused on aggregate level by province. It is necessary to future investigate at the two-digit sector level by province.

To our knowledge, this paper is the first one to identify the keys for energy conversation across the 31 provinces ×65 sectors. We use comparison analysis on provinces and sectors. The results are show in Fig. 5, Table 2 and 3 in detail. They are visualized and easy for using. Different provinces have different key sectors, and different sectors have different provinces for energy conservation.

Due to the data limitations, there are some deficiencies in this paper. Firstly, we use the linear summation method to aggregate various energy types according to their heat or coal equivalents regardless the heterogeneity and imperfect substitutability among them. Secondly, we only investigate the provincial energy consumption at the two-digit sector level. There would be more interesting and operational suggestions at the four-digit sector or product level. We hope we can improve it in future study.

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Figures

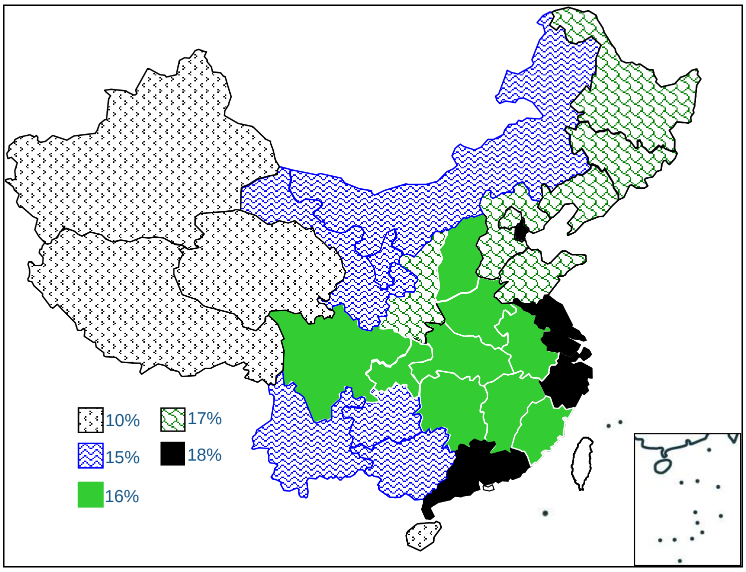


Fig.1. China's provincial assignment of energy intensity reduction in 2011-2015. It is a schematic map and does NOT implicate the definite boundaries. The numbers refer to the assigned reduction rate.) Source: State Council [2].

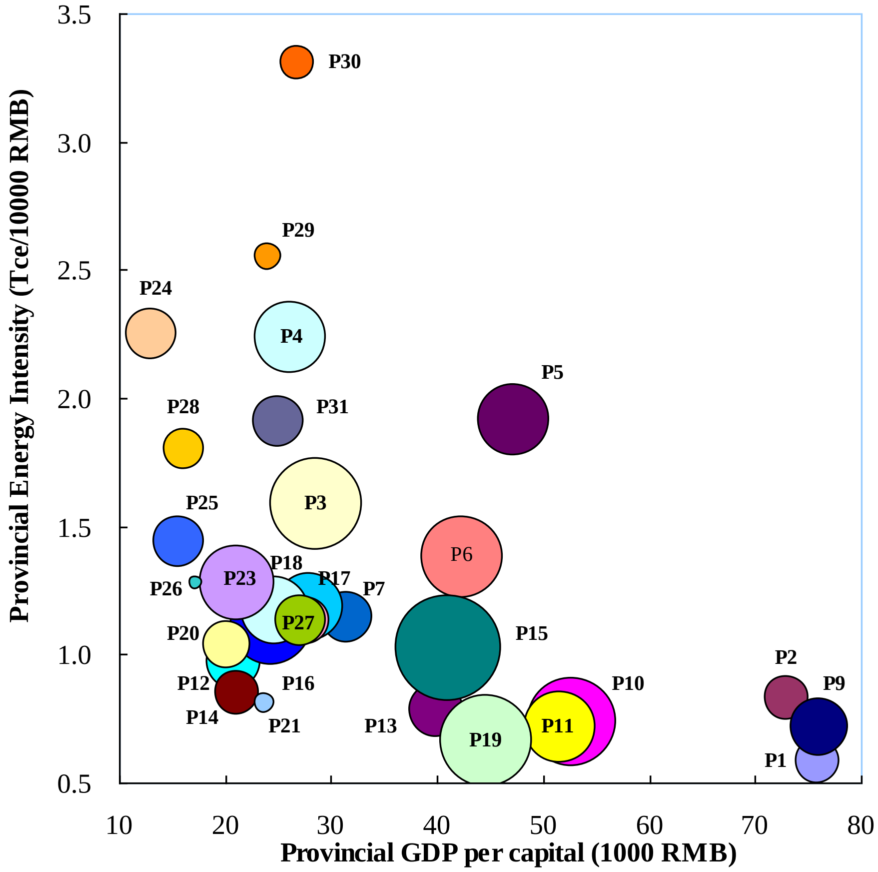


Fig. 2. China's provincial GDP per capital, energy intensity and energy consumption. Pj ($j = 1,\cdots,31$) refers to the province code as shown in Fig. 3, and the corresponding circle area represents the energy consumption volume of this province.

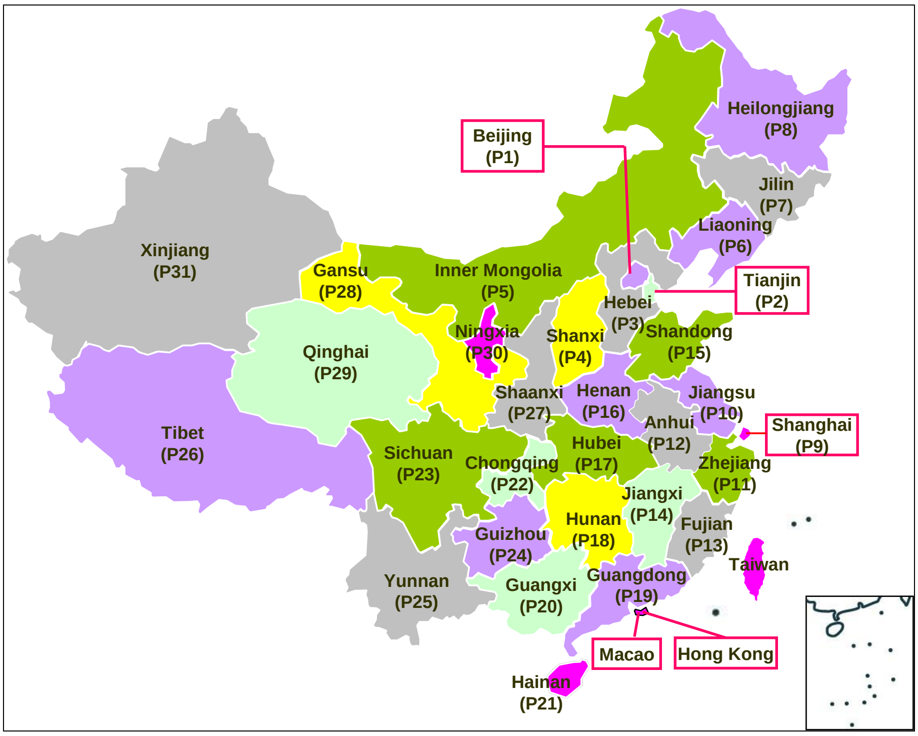
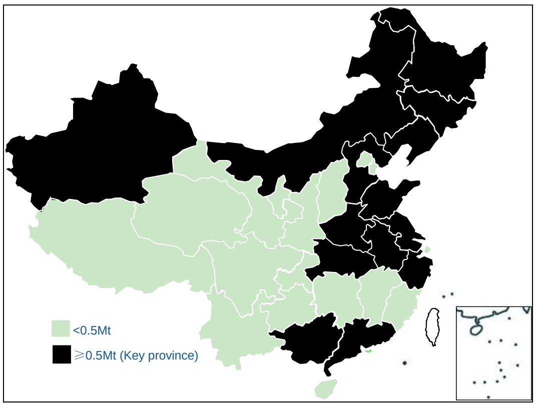
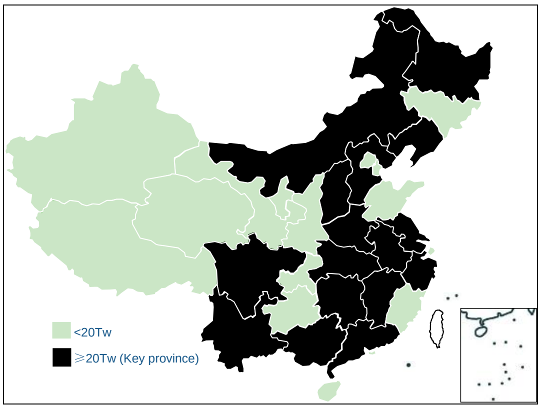


Fig.3. Province name and their codes. Note: (1) the codes in parenthesis represent corresponding provinces in Mainland China. (2) it is a schematic map and does NOT implicate the definite boundaries.



a) Diesel



b) Electricity

Fig.4. Key provinces for energy conservation in China. It is a schematic map and does NOT implicate the definite boundaries. Data source: Department of Agriculture [13].

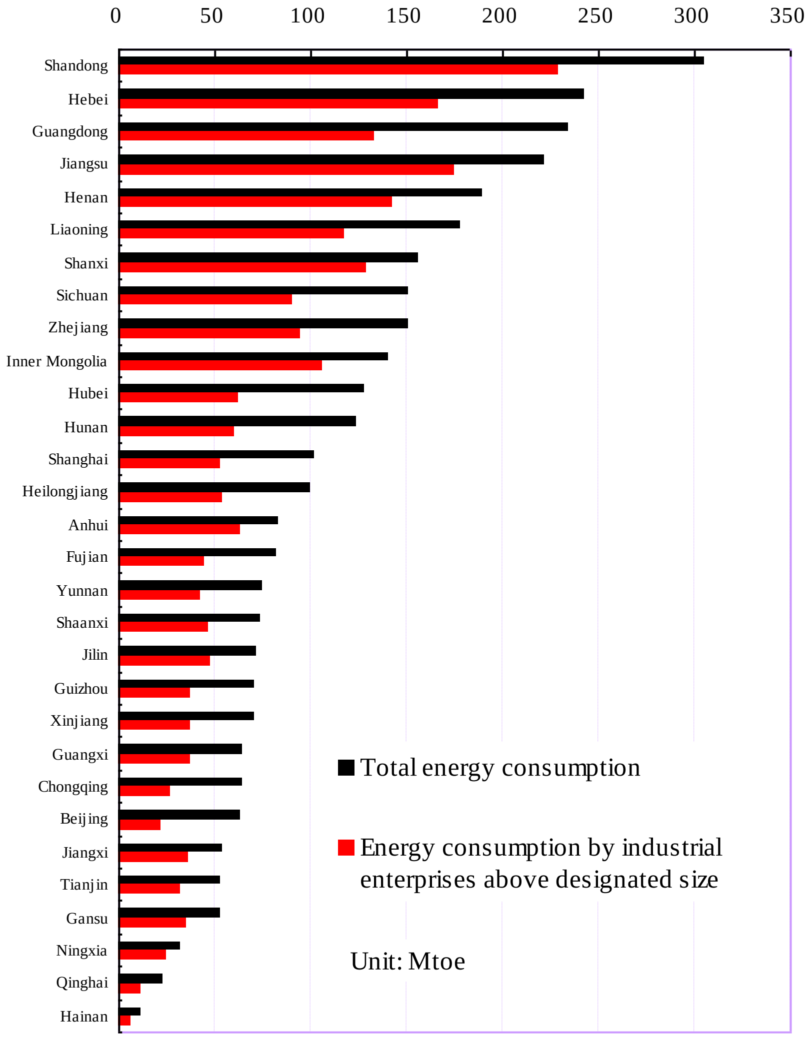


Fig.5. Industrial energy consumption by province in 2008 in China. Data sources: the Second National Economic Census Office [12] and authors' calculations.

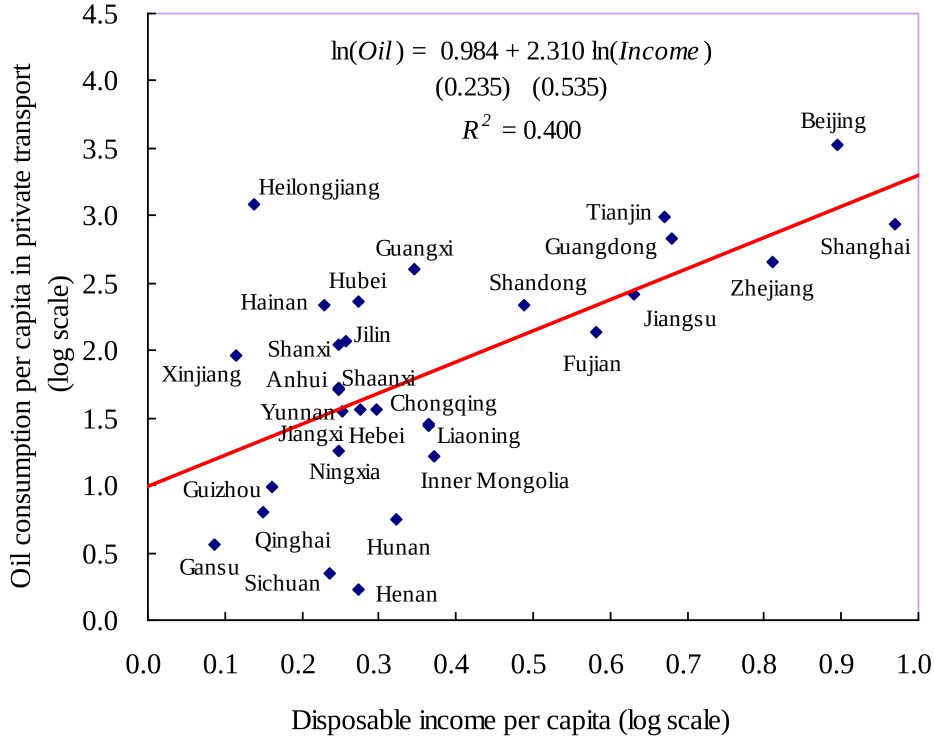


Fig.6. China's urban residential oil consumption and income per capita. In the regression equations, values in parentheses are standard errors, and they are statistically significant at 1% level. Data sources: [19, 20] and authors' calculations.

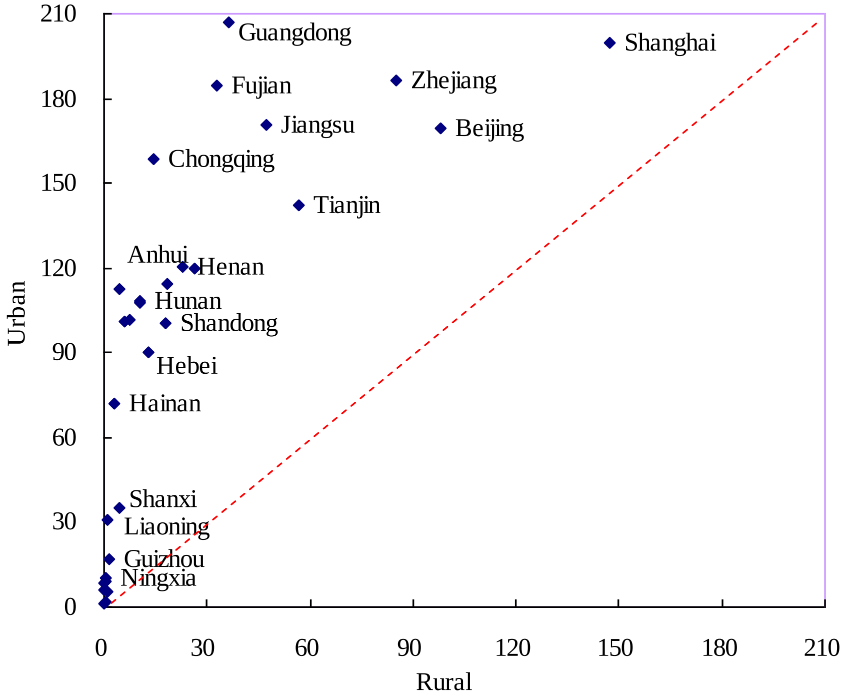


Fig.7. Air-condition ownerships per 100 households across China's provinces in 2010. Data sources: [20] and authors' calculations.

Tables

Table 1. Sector full names and their codes

Code	Full name of sectors	Code	Full name of sectors
S1	Agriculture	S34	Manufacture of Communication Equipment, Computers and Other Electronic Equipment
S2	Mining and Washing of Coal	S35	Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work
S3	Extraction of Petroleum and Natural Gas	S36	Manufacture of Artwork and Other Manufacturing
S4	Mining and Processing of Ferrous Metal Ores	S37	Recycling and Disposal of Waste
S5	Mining and Processing of Non-Ferrous Metal Ores	S38	Production and Supply of Electric Power and Heat Power
S6	Mining and Processing of Nonmetal Ores	S39	Production and Supply of Gas
S7	Mining of Other Ores	S40	Production and Supply of Water
S8	Processing of Food from Agricultural Products	S41	Construction
S9	Manufacture of Foods	S42	Transport via Railway
S10	Manufacture of Beverages	S43	Transport via Road
S11	Manufacture of Tobacco	S44	Urban Public Traffic
S12	Manufacture of Textile	S45	Water Transport
S13	Manufacture of Textile Wearing Apparel, Footwear and Caps	S46	Air Transport
S14	Manufacture of Leather, Fur, Feather and Related Products	S47	Transport via Pipeline
S15	Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm and Straw Products	S48	Loading, Unloading, Portage and other Transport Services
S16	Manufacture of Furniture	S49	Storage
S17	Manufacture of Paper and Paper Products	S50	Post
S18	Printing, Reproduction of Recording Media	S51	Wholesale and Retail Trade
S19	Manufacture of Articles For Culture, Education and Sport Activities	S52	Accommodation and Restaurants
S20	Processing of Petroleum, Coking, Processing of Nuclear Fuel	S53	Information Transfer, Computer Services and Software
S21	Manufacture of Raw Chemical Materials and Chemical Products	S54	Finance
S22	Manufacture of Medicines	S55	Real Estate

Code	Full name of sectors	Code	Full name of sectors
S23	Manufacture of Chemical Fibers	S56	Tenancy and Business Services
S24	Manufacture of Rubber	S57	Scientific Research, Technical Service and Geologic Perambulation
S25	Manufacture of Plastics	S58	Management of Water Conservancy, Environment and Public Establishment
S26	Manufacture of Non-metallic Mineral Products	S59	Resident Services and other Services
S27	Smelting and Pressing of Ferrous Metals	S60	Education
S28	Smelting and Pressing of Non-ferrous Metals	S61	Sanitation, Social Security and Social Welfare
S29	Manufacture of Metal Products	S62	Culture, Sports and Entertainment
S30	Manufacture of General Purpose Machinery	S63	Public Management and Social Organization
S31	Manufacture of Special Purpose Machinery	S64	Urban Residential
S32	Manufacture of Transport Equipment	S65	Rural Residential
S33	Manufacture of Electrical Machinery and Equipment		

Table 2. The key and most-key province ×sector for energy conservation in China's industrial and construction sectors.

Code[a]	Gini[b]	x%[c]	Province[d]																														
			P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31
S2	0.44	80%			★[b]	★	★	★		★				★			★	★							★								
S3	0.33	95%		★	★			★	★	★							★	★							★				★		★		★
S4	0.52	-																															
S5	0.44	-																															
S6	0.34	-																															
S7	-	-																															
S8	0.48	80%			★		★	★	★	★		★					★	★			★	★			★								
S9	0.45	-																															
S10	0.37	-																															
S11	0.45	-																															
S12	0.31	75%										★	★				★				★												
S13	0.30	-																															
S14	0.33	-																															
S15	0.39	-																															
S16	0.44	-																															
S17	0.40	80%			★							★	★		★		★	★		★		★			★								
S18	0.45	-																															
S19	0.34	-																															
S20	0.35	82%	★		★	★	★	★		★	★						★				★				★				★	★			★
S21	0.54	85%			★	★	★	★	★		★	★	★	★			★	★	★	★	★				★		★		★			★	
S22	0.38	-																															
S23	0.53	-																															
S24	0.46	-																															
S25	0.42	-																															
S26	0.46	81%			★			★				★	★	★	★	★	★	★	★	★	★	★		★	★								

Code[a]	Gini[b]	x%[c]	Province[d]																														
			P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31
S27	0.44	95%		★	★	★	★	★	★		★	★	★	★	★	★	★	★	★	★	★	★			★	★	★			★			
S28	0.39	95%				★	★	★				★				★	★	★	★	★	★	★			★	★	★		★	★	★	★	
S29	0.41	90%		★	★			★			★	★	★				★	★	★	★	★				★	★							
S30	0.40	82%			★			★			★	★	★				★	★	★		★				★								
S31	0.40	-																															
S32	0.31	83%		★	★			★	★		★	★	★				★	★	★		★			★	★				★				
S33	0.42	-																															
S34	0.39	92%	★	★							★	★	★				★	★		★	★				★				★				★
S35	0.44	-																															
S36	0.54	-																															
S37	-	-																															
S38	0.35	85%			★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★				★	★			★	★			
S39	0.32	-																															
S40	0.52	-																															
S41	-	-																															

[a] Si ($i = 1, \cdots, 39$) is the sector name code, and Pj ($j = 1, \cdots, 31$) is the province name code. Their full names are listed in Appendix II.

[b] Gini coefficients by sector are listed on the left column.

[c] "x%" implicates the energy consumption of the corresponding sector is over 20 Mtce and represents the share of the total energy consumption of those key (i, j) (i.e. labeled with ★) in the whole sector i .

[d] The cells labeled with ★ are *key* province×sectors for energy conservation, and those further with gray color filled are the *most key* province×sectors for energy conservation (energy intensity $e_{ij} > 0.7\overline{e_i}$).

Table 3. The key province×sector for energy conservation in China's tertiary industry.

Code	Department and Province[a]																																	
	A1[b]	A2[c]	A3[d]	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31
S42	★																																	
S43		★	★																															
S44				★	★	★			★	★	★	★	★	★	★	★		★	★	★	★	★				★				★				
S45		★	★																															
S46		★	★																															
S47																																		
S48																																		
S49																																		
S50																																		
S51				★		★	★		★			★	★	★				★	★	★	★	★				★		★		★				
S52				★								★	★	★				★	★	★	★	★				★								
S53																																		
S54																																		
S55				★	★				★			★	★	★	★			★		★	★	★			★	★								
S56																																		
S57																																		
S58																																		
S59																																		
S60				★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★				★				★
S61																																		
S62	31 capital cities of provinces and five special municipalities (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen) are the keys																																	
S63				★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★		★	★	★	★	★

[a] The cells labeled with ★ are *key* province×sectors for energy conservation.

[b] A1 represents Ministry of Railway.

[c] A2 represents Ministry of Industry and Information.

[d] A3 represents Ministry of Transport.

Table 4. Energy consumption in residential and some tertiary industries in 2008 in Beijing[a].

Code	Sector name	Energy		Electricity	Oil
		Total (ktce)	Per capita (tce)	Per capita (MWh)	Per capita (t)
S44	Urban Public Traffic	1462	0.083	-	-
S54	Finance	382	1.52	2.85	0.14
S55	Real Estate	3232	7.89	10.94	0.15
S56	Tenancy and Business Services	1294	1.35	2.11	0.12
S57	Scientific Research, Technical Service and Geologic Perambulation	981	1.74	2.50	0.14
S58	Management of Water Conservancy, Environment and Public Establishment	258	2.78	4.39	0.50
S59	Resident Services and other Services	252	1.79	2.14	0.14
S60	Education	1512	3.51	4.34	0.11
S61	Sanitation, Social Security and Social Welfare	538	2.70	3.86	0.07
S62	Culture, Sports and Entertainment	462	2.48	4.35	0.12
S63	Public Management and Social Organization	908	2.48	3.43	0.27
S64 S65	Urban and Rural Residential	-	-	0.70	-

[a] Data sources: The Second Beijing Economic Census Office [17] and authors' calculations.