***Supplementary Material***

1. **The setting of decent living standards in China**

## Decent living standards

Rao and Baer (2012) propose a conceptual framework for decent living. Rao and Min (2018) define a set of universal, nonsimplifiable material conditions for achieving basic human well-being, including indicators and thresholds for these conditions, called the decent living standards (DLS). These indicators and thresholds can be adjusted to account for local customs and preferences in different regions. The DLS is designed to serve as a ‘lowest common denominator’ of basic material requirements that are instrumental (but not sufficient) to achieve physical, and to an extent social, dimensions of human well-being, whether conceived as basic needs or basic capabilities, and independent of peoples’ values or relative stature in society. The DLS has three principles. First, the constituents of a DLS must be necessary and indispensable or otherwise globally desired. One basic need or capability is at least satisfied; the fulfilment of others’ needs or capabilities is not harmed; it is the only satisfier of at least one basic need or capability, or it is one of many competing satisfiers and overwhelmingly preferred within the realm of at least one dimension. Second, a DLS holds basic human well-being to an acceptable threshold by limiting the risks. Third, material requirements at the household, community or societal level are supported by individual entitlements.

China's DLS is established based on this standard (**Supplementary Table 1**). However, considering the differences in development levels, cultures, regions and living habits between countries, the DLS of Chinese residents should be adjusted reasonably according to the actual situation. The DLS in this study is set based on the actual situation in China, combined with relevant policies and industry standards (**Supplementary Table 2**).

**Supplementary Table 1** Decent living standards

|  |  |  |
| --- | --- | --- |
| Categories | | Decent living standards |
| Food | Food | Satisfy the general caloric needs of residents |
| Refrigerator | Medium size refrigerator |
| Clothing |  | Adequate clothing for prevailing climatic conditions |
| Transportation |  | Fully meet people's general motor transportation needs |
| Housing | Thermal comfort | Modern heating or cooling equipment to ensure people are in a comfortable environment |
| Light | Electrical lighting |
| Information and communication | One telephone, one TV or computer per household |
| Cooking |  | Modern stoves, gas fuel or electricity |
| Water |  | Adequate water supply |
| Health care |  | Generally satisfactory, adequate and accessible preventive and curative health care facilities |
| Education |  | Generally satisfactory and adequate educational facilities and staff |

**Supplementary Table 2** Decent living standards in China

|  |  |  |  |
| --- | --- | --- | --- |
| Consumption categories |  | DLS (Rao and Min, 2018) | DLS of China |
| Food |  | Total calories | Daily calorie requirements for men and women of different ages (kcal/per) |
| Clothing |  | Minimum clothing materials | Yearly clothing weights for men, women and children at different temperatures Number of suits: 2.3 /person |
| Transportation |  | Access to public transport, or vehicle, if essential | Urban: public transportation Rural: public and private transportation |
| Housing | Cooling | Basic comfort (fans and AC, if needed) | AC size:1.5HP Power: 0.302kW/h Hours of use: 8h(weekdays);10h(weekends) Temperature threshold:26℃ |
| Heating | Heating area：117(㎡/household) AC size:1.5HP Power:0.674kW/h  Operation time:3h/day Temperature threshold:18℃ |
| Light | Electrical lighting | Power density:5(W/㎡) Area: living room 36㎡;host bedroom:32.4㎡;secondary bedroom:18㎡ |
| Refrigerator | Medium size refrigerator | Size:150l(Rao et al. 2019) Electricity:0.33(kWh/d) |
| TV | 1 TV or computer/household | TV:1 /household |
| Mobile phone | 1/ household | Phone:1/person |
| Cook |  | Clean cook stoves gaseous fuel or electricity | Gaseous fuel or electricity |
| Water |  | Minimum accessible water supply | 100L/(per⋅day) |
| Health care |  | Accessible and adequate health care facilities | ¥4614.96(per⋅d) |
| Education |  | Primary and secondary schooling | Full coverage of nine-year compulsory education  Expenditure: primary school ¥6939.79/(per⋅yr); middle school ¥10409.68/(per⋅yr) |

## Food

The DLS for food is based on the*Dietary Reference Intakes* (DRI) *for Chinese Residents* (*2013*)[[1]](#footnote-1). DRIs are a set of reference values for the average daily dietary nutrient intake based on the recommended dietary nutrient supply. It ensures an adequate intake of nutrients by the human body, avoids insufficiency and excess, and enables people to control their own nutritional intake by referencing it. DRIs mainly include four components: estimated average requirement (EAR), recommended nutrient intake (RNI), adequate intake (AI), and tolerable upper intake level (UL). The EAR is based on research data on individual requirements. It is an intake level that meets 50% of the individual requirements for a specific gender, age and physical condition group based on certain indicators. This intake level does not meet the needs of the other 50% of individuals for this nutrient. RNI is the intake level that can meet the requirements of the vast majority (97% ~ 98%) of individuals in a specific gender, age and physical condition group. Long-term intake of RNI levels can meet the body's need for this nutrient to stay healthy and maintain proper reserves in body tissues. The primary use of RNI is as an individual's target daily intake of a nutrient. AI is used to replace RNI when RNI cannot be obtained. Since EAR cannot be calculated when data on individual requirements are insufficient, RNI cannot be obtained. AI is the intake of a certain nutrient in healthy people obtained through observation or experimentation. UL is the maximum daily intake of a nutrient. This intake is not harmful to the health of nearly all individuals in the general population.

The standard of food requirement under the DLS in this study is based on the RNI (**Supplementary Table 3**).

**Supplementary Table 3** Daily caloric needs of men and women of different ages

|  |  |  |
| --- | --- | --- |
| Age | Caloric requirement (Kcal) | |
|  | Male | Female |
| 0- | 715 | 665 |
| 1- | 1100 | 1050 |
| 2- | 1200 | 1150 |
| 3- | 1350 | 1300 |
| 4- | 1400 | 1400 |
| 5- | 1600 | 1500 |
| 6- | 1700 | 1600 |
| 7- | 1800 | 1700 |
| 8- | 1900 | 1800 |
| 9- | 2000 | 1900 |
| 10- | 2100 | 2000 |
| 11- | 2400 | 2200 |
| 14- | 2900 | 2400 |
| 18- | 2767 | 2367 |
| 50- | 2667 | 2033 |
| 60- | 2050 | 2100 |
| 70- | 2000 | 1800 |
| 80- | 1900 | 1700 |

Note: The caloric requirements of infants under 1 year old were obtained by multiplying the average weight of male and female infants (7.5kg,7kg) (China Reference Standards for Children Under 7 Years of Age) by the RNI standard (95kcal/kg).

## Clothing

The DLS for clothing is based on weight and sales. This study assumes that the required weight of clothing increases as the temperature decreases.

According to the weight of various types of clothing[[2]](#footnote-2), we set the weight of the clothing for men, women and children at the highest and lowest temperatures. On this basis, we divide the temperature into eight levels and then set eight corresponding clothing weights according to the temperature (**Supplementary Table 4**). Data from the *National Bureau of Statistics of China*[[3]](#footnote-3) show that China's clothing sales were 54.06 billion pieces in 2017, approximately 39 pieces per person. Surveys[[4]](#footnote-4) show that China wastes 26 million tons of clothing every year, approximately 37 pieces per person. Chinese residents' demand for clothing is between 37-39 pieces, and most of the clothing are kept for only 1 year. To ensure the diversity of clothing consumption of Chinese residents and avoid waste, the DLS in this study assumes that the annual per capita clothing demand is 38 pieces, and the use time is 3 years; that is, the per capita annual clothing consumption is approximately 13 pieces. In this study, the monthly average temperature of each temperature zone in 2017 was divided into 8 grades. The weights of clothing corresponding to the temperature levels contained in each temperature zone were added (**Supplementary Table 5**) to obtain the annual required clothing weight per person in the corresponding temperature zone (**Supplementary Table 4**).

**Supplementary Table 4** Clothing weights for different temperatures and temperature zones

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Weight of clothing（g) | | |
|  |  | Male | Female | Children |
| Temperature（℃） | （-∞，-25） | 4045 | 3693 | 2935 |
| （-25，-15） | 3559 | 3220 | 2540 |
| （-15，-5） | 3074 | 2748 | 2145 |
| （-5，5） | 2588 | 2275 | 1751 |
| （5，15） | 2102 | 1803 | 1356 |
| (15,25) | 1616 | 1331 | 961 |
| (25,35) | 1131 | 858 | 566 |
| (35,+∞） | 645 | 386 | 171 |
| Temperature zones | Cool temperate zone | 12939 | 11377 | 8753 |
| Middle Temperate Zone | 10511 | 9015 | 6779 |
| Warm temperate zone | 10511 | 9015 | 6779 |
| Subtropics | 4849 | 3992 | 2883 |
| Tropics | 2747 | 2189 | 1527 |
| Plateau climate zone | 9380 | 8157 | 6213 |

**Supplementary Table 5** Temperature distribution in different temperature zones

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Temperature（℃） | Temperature zones | | | | | |
| Cool temperate zone | Middle Temperate Zone | Warm temperate zone | Subtropics | Tropics | Plateau climate zone |
| （-∞，-25） |  |  |  |  |  |  |
| （-25，-15） | √ |  |  |  |  |  |
| （-15，-5） | √ | √ | √ |  |  | √ |
| （-5，5） | √ | √ | √ |  |  | √ |
| （5，15） | √ | √ | √ | √ |  | √ |
| (15,25) | √ | √ | √ | √ | √ | √ |
| (25,35) |  | √ | √ | √ | √ |  |
| (35,+∞） |  |  |  |  |  |  |

## Transportation

The DLS set for transportation in Rao and Min (2018) includes adequate public transportation and basic road infrastructure in urban areas. Private vehicles may only be required in sparsely populated and remote areas. Based on the standard, China's DLS is set as follows: urban residents' transportation is entirely provided by public transportation, and rural areas are provided by public and private transportation. Considering that China has a large area with obvious differences in topography and population densities, the residential travel demand varies. To guarantee the basic transportation demand of Chinese residents, the travel demand data in 2017 are still used in the DLS scenario. The energy consumption coefficients of different types of vehicles are based on the actual data in the *World Energy Outlook-2017 Special Report* (ETP2017) published by the *International Energy Agency* (IEA)[[5]](#footnote-5).

## Housing-cooling

This study assumes that all cooling is provided by air conditioning. Data from the *China Statistical Yearbook (2018)[[6]](#footnote-6)* show that, in 2017, the number of air conditioners per 100 households in urban areas was 142.2 units; the number of air conditioners per 100 households in rural areas was 65.2 units. Accordingly, this study sets the number of air conditioners in rural and urban areas in the DLS scenario to be 1 unit per household. The selection of air conditioners (AC) is based on the existing air conditioner data in China, and a 1.5 HP AC with first-class energy efficiency is selected. According to the *Labour Law and Healthy China Action* (*2019-2030*)[[7]](#footnote-7), the air conditioner is used for 8 hours on weekdays and 10 hours on weekends. According to the *People's Republic of China Industry Standard-Standard for* *Weather Data of Building Energy Efficiency* (*JGJ/T 346-2014*)[[8]](#footnote-8), 26 °C is used as the temperature limit for cooling; that is, when the temperature is higher than 26 °C, cooling is needed. The operating parameters of AC are shown in **Supplementary Table 6**.

**Supplementary Table 6** Parameters of air conditioner

|  |  |
| --- | --- |
| Parameters | Value |
| Size (PH) | 1.5 |
| Cooling power(kW/h) | 0.302 |
| Heating power(kW/h) | 0.67 |
| Cooling duration (Weekdays) | 12：00-14：00 |
| 18：00-24：00 |
| Cooling duration (Weekends) | 11：00-14：00 |
| 17：00-24：00 |
| Heating duration | 3h/d (Qu and Gao, 2016) |

Note: The cooling and heating power is obtained by dividing the seasonal power consumption by the number of operation hours. The national standard stipulates that when calculating the energy efficiency of inverter air conditioners, the cooling season in a year is calculated as 1136 hours, and the heating season is calculated as 433 hours.

## Housing-heating

Taking the Qinling-Huaihe Line as the boundary, central heating is only deployed in the north and only in urban areas. However, the study suggests promoting the district heating market in appropriate areas in South China (Guo et al., 2015). The *People's Republic of China Industry Standard-Standard for Weather Data of Building Energy Efficiency* (*JGJ/T 346-2014*)[[9]](#footnote-9)stipulates that heating is required when the room temperature is below 18℃ in winter. Therefore, the DLS of heating in this study designates that there is a heating demand when the temperature is lower than 18 ℃. On this premise, the heating area and the duration of the heating period are obtained (**Supplementary Table 6**). The northern region refers to the *People's Republic of China Industry Standard-Standard for Weather Data of Building Energy Efficiency (JGJ/T 346-2014)*. The heating period in the southern regions is estimated based on Eq. (S1). Through a survey of 5,000 households in the southern region, we found that AC is the main heating method of residents, accounting for 50% (Han et al., 2022). Therefore, it is assumed that ACs are used for heating in southern regions and rural areas for the DLS scenario. The heating area refers to the actual per capita housing area of 39 in China[[10]](#footnote-10).

（S1）

where Z is the number of heating duration days and M is the number of months with an average monthly temperature below 18 ℃.

## Housing-lighting

The setting of the DLS for lighting includes the duration of lighting and the type of luminaires, as shown in **Supplementary Table 7**. The selection of luminaires is based on the target value of lighting power density for residential buildings in relevant regulations on lighting energy savings (*Standard for Lighting Design of Buildings*)[[11]](#footnote-11). Because the lighting time of the bathroom and kitchen cannot be estimated and the proportion is very small, this study only considers the lighting of the living room and bedroom and stipulates that the lighting of the living room and the bedroom should not be used at the same time. For the lighting area, since the size of the room determines the power of the lamp, the lighting time of each room is also different, so refer to the total area in 1.6 and combine with the *Residential Design Specification* (*GB 50096-2011*)[[12]](#footnote-12) to set parameters for different rooms; details are shown in **Supplementary Table 7**.

**Supplementary Table 7** Lighting parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Type of room | Lighting power density(LPD)(W/㎡) | Room size(㎡) | Power of the lamp(W) | Energy consumption per minute(J) | Operation hours |
| Living room | 5 | 36 | 180 | 10800 | Weekdays: 7:00~Daybreak; Nightfall~22:00 Weekends: 8:00~Daybreak; Nightfall~23:00 |

## Housing-electronic devices

For the DLS, electronic devices include TVs, phones and refrigerators, with one TV and refrigerator per household and one phone per person (Rao et al., 2019). The specific parameters are shown in **Supplementary Table 8**. The electricity consumption of TVs and mobile phones refers to a previous study (Malmodin et al., 2010). The parameters of the most energy-saving refrigerator in the market in China are referred to in the DLS scenario.

**Supplementary Table 8** Parameters of electronic devices

|  |  |  |
| --- | --- | --- |
| Devices | Parameters | Value |
| TV | Electricity consumption per year(kW⋅h) | 3 |
| Phone | 200 |
| Refrigerator | Size(L) | 150 |
| Power consumption per day(kW⋅h) | 0.33 |

## Health care

Rao and Min (2018) estimate an annual expenditure of $450–700 per capita, corresponding to the average cost of the more efficient half of countries. This study takes the median value $665 as the DLS in China, which is RMB 4614.96 yuan considering the exchange rate and inflation.

## Education

China's DLS is set considering the number of people educated and educational expenditure. We assume that all people follow the nine-year compulsory education. Regarding expenditure, Rao et al. (2019) selected countries where at least 80 percent of adults have completed secondary education and used their average expenditure per student on primary for $1000 and lower and upper secondary education for $1,500 as the DLS threshold. This standard is the average value of many countries and can reflect the general educational needs of human beings, so we follow this standard and consider exchange rate and inflation to be converted into RMB 6939.79 yuan and RMB 10409.78 yuan.

## Water

According to The Standard of *Water Quantity for City's Residential Use*[[13]](#footnote-13) published in 2020, the basic water consumption that can be satisfied for urban residents per day should not be less than 100 L. Therefore, this study stipulates that for the DLS scenario, 100 L of water per day per capita for residents should be ensured.

## Cooking

The DLS for cooking is set from the fuel types and proportions. In actual situations, the cooking fuels used by Chinese residents mainly include firewood, coal, liquified petroleum gas (LPG), natural gas, biogas and electricity; their energy efficiency is shown in **Supplementary Table 10** (Ekholm et al., 2010). For the DLS, the cooking fuels are only electricity and gas (**Supplementary Table 1**), and the proportion of these two fuels is based on the actual proportion of each to the sum of each as noted in the *China Family Panel Studies* (CFPs)[[14]](#footnote-14) (**Supplementary Table 9**). To ensure that the cooking energy needs of the residents are met, we stipulate that the DLS scenario except the waste due to energy efficiency is the same as the actual situation.

**Supplementary Table 9** Proportion of electricity and gas used for cooking

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Province | The proportion of electricity | The proportion of gas | Province | The proportion of electricity | The proportion of gas |
| Beijing | 23.94% | 76.06% | Henan | 26.91% | 73.09% |
| Tianjin | 10.95% | 89.05% | Hubei | 3.74% | 96.26% |
| Hebei | 39.44% | 60.56% | Hunan | 9.79% | 90.21% |
| Shanxi | 63.86% | 36.14% | Guangdong | 26.14% | 73.86% |
| Inner Mongolia | 54.55% | 45.45% | Guangxi | 62.29% | 37.71% |
| Liaoning | 20.60% | 79.40% | Hainan | 33.33% | 66.67% |
| Jilin | 29.54% | 70.46% | Chongqing | 20.09% | 79.91% |
| Heilongjiang | 58.33% | 41.67% | Sichuan | 27.82% | 72.18% |
| Shanghai | 5.45% | 94.55% | Guizhou | 87.55% | 12.45% |
| Jiangsu | 7.82% | 92.18% | Yunnan | 90.89% | 9.11% |
| Zhejiang | 9.80% | 90.20% | Shaanxi | 35.21% | 64.79% |
| Anhui | 16.67% | 83.33% | Gansu | 55.81% | 44.19% |
| Fujian | 60.27% | 39.73% | Qinghai | 55.81% | 44.19% |
| Jiangxi | 10.22% | 89.78% | Ningxia | 55.81% | 44.19% |
| Shandong | 23.95% | 76.05% | Xinjiang | 28.93% | 71.07% |

**Supplementary Table 10** Efficiency of different fuels

|  |  |
| --- | --- |
| Type of fuel | Efficiency |
| Firewood | 15% |
| Electricity | 75% |
| Liquefied gas | 60% |
| Coal | 15% |
| Solar energy | 55% |
| Natural gas | 60% |

1. **Methods**
   1. **Direct energy consumption**
      1. **Transportation**

The actual transportation energy consumption is calculated as follows: the energy consumption coefficient () of different vehicles, including air, railways and roads (including light roads and heavy roads), is first calculated by Eq. (S2). The actual mileage of private and public transportation for residents is then calculated, in which the mileage of private transportation (R) is calculated as Eq. (S3), and the passenger turnover data of public transportation are collected from the *China Statistical Yearbook (2018)*. The actual transportation energy consumption of each province () is calculated by Eq. (S4).

(S2)

(S)

(S)

where and are the energy consumption and passenger mileage of vehicle i, respectively; and represent rural and urban populations, respectively; and denote the number of private vehicles per 100 households in rural and urban areas, respectively; is the average annual mileage of each private vehicle.

The transportation energy consumption for the DLS scenario is calculated using the same method as in the actual situation. As Rao and Min's DLS stated, in sparsely populated remote areas only, household ownership of vehicles may be necessary. The Chinese DLS scenario in this study was adjusted considering that the mileage of the private transportation part of the urban area is all replaced with the public transportation.

* + 1. **Housing**

In actual situations, the energy consumed by residential housing demand mainly includes electricity, heat and coal. Because the calculation of detailed categories according to the existing data is not accurate enough, only the total energy consumption of housing is calculated here by adding up the total residential consumption of electricity, heat and coal and then removing the portion used for cooking. The electricity, heat and coal data come from the total electricity and heat consumption () and coal consumption () of residents in each province (*China Statistical Yearbook*). The actual direct energy consumption of housing in each province is shown in **Supplementary Table 11**.

For the DLS, housing is divided into different categories for calculation, including cooling, heating, light and electric appliances, and the calculation method is as follows.

(1) Cooling. The procedure for calculating cooling energy consumption for the DLS scenario is shown below: the energy consumption of each household in each temperature zone () is first calculated using Eq. (S5) by calculating the average cooling energy consumption of each household in representative cities of each temperature zone. The selected representative cities include the Daxing 'an Mountains, Changchun, Hohhot, Urumqi, Beijing, Xi'an, Aksu, Shanghai, Wuhan, Chongqing, Haikou, Xining and Ali areas. The energy consumption of each province for the DLS () is then calculated by Eq. (S6).

(S)

(S)

where represents the number of households in each province and represents the energy consumption per household in the province. Considering that China has been divided into six regions by temperature zone, a representative province is selected in each region, and the energy consumption per household of the representative province is used as the energy consumption per household of all provinces in the temperature zone; and represent the daily cooling hours on weekdays and weekends; and represent the annual cooling days on weekdays and weekends; and represents AC’s cooling power (kW). The populations of different temperature zones in different provinces are shown in **Supplementary Table 12**.

**Supplementary Table 11** The actual direct energy consumption of housing

|  |  |  |  |
| --- | --- | --- | --- |
| Province | Energy consumption(bn⋅kJ) | Province | Energy consumption(bn⋅kJ) |
| Beijing | 309.09 | Henan | 663.65 |
| Tianjin | 213.26 | Hubei | 141.77 |
| Hebei | 692.79 | Hunan | 146.43 |
| Shanxi | 374.26 | Guangdong | 192.34 |
| Inner Mongolia | 396.31 | Guangxi | 62.74 |
| Liaoning | 803.00 | Hainan | 12.45 |
| Jilin | 421.86 | Chongqing | 63.53 |
| Heilongjiang | 595.55 | Sichuan | 182.69 |
| Shanghai | 52.93 | Guizhou | 73.52 |
| Jiangsu | 228.67 | Yunnan | 55.40 |
| Zhejiang | 117.63 | Shaanxi | 318.39 |
| Anhui | 212.20 | Gansu | 278.45 |
| Fujian | 37.78 | Qinghai | 85.14 |
| Jiangxi | 103.56 | Ningxia | 97.59 |
| Shandong | 1013.04 | Xinjiang | 346.17 |

**Supplementary Table 12** The population of different temperature zones (10 thousands)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Province | Cold temperate zone | Mid-temperate zone | Warm temperate zone | Subtropics | Tropics | Plateau climate zone |
| Beijing |  |  | 2171 |  |  |  |
| Tianjin |  |  | 1557 |  |  |  |
| Hebei |  |  | 7520 |  |  |  |
| Shanxi |  |  | 3702 |  |  |  |
| Inner Mongolia | 253 | 2276 |  |  |  |  |
| Liaoning |  | 1067 | 3302 |  |  |  |
| Jilin |  | 2717 |  |  |  |  |
| Heilongjiang | 43 | 3746 |  |  |  |  |
| Shanghai |  |  |  | 2418 |  |  |
| Jiangsu |  |  | 2312 | 5717 |  |  |
| Zhejiang |  |  |  | 5657 |  |  |
| Anhui |  |  | 2638 | 3617 |  |  |
| Fujian |  |  |  | 3911 |  |  |
| Jiangxi |  |  |  | 4622 |  |  |
| Shandong |  |  | 10006 |  |  |  |
| Henan |  |  | 644 | 8915 |  |  |
| Hubei |  |  |  | 5902 |  |  |
| Hunan |  |  |  | 6860 |  |  |
| Guangdong |  |  |  | 10447 | 722 |  |
| Guangxi |  |  |  | 4885 |  |  |
| Hainan |  |  |  |  | 926 |  |
| Chongqing |  |  |  | 3075 |  |  |
| Sichuan |  |  |  | 7936 |  | 366 |
| Guizhou |  |  |  | 3580 |  |  |
| Yunnan |  |  |  | 4683 | 118 |  |
| Shaanxi |  |  | 3229 | 606 |  |  |
| Gansu |  |  | 2349 |  |  | 277 |
| Qinghai |  |  |  |  |  | 598 |
| Ningxia |  | 559 | 123 |  |  |  |
| Xinjiang |  | 1191 | 1254 |  |  |  |

(2) Heating. The central heating energy consumption per household) is first calculated in Eq. (S7). The total energy consumption of central heating in each province () is then quantified by Eq. (S8). The energy consumption in noncentral heating areas (), including rural areas north of the Qinling-Huaihe Line and all areas south of the Qinling-Huaihe Line, is calculated by Eq. (S9). The heating energy consumption of each province () is the sum of the results of Eq. (S8) and Eq. (S9).

(S7)

where Z represents the annual heating days; is the heating coal consumption index (kg/), representing coal consumption for heating for 1 per day; S represents the heating building area (); represents the calorific value of standard coal; represents the outdoor pipe network transmission efficiency; and represents the boiler operation efficiency.

(S8)

(S9)

where represents daily heating hours and represents AC’s heating power (kW).

(3) Housing-Lighting. The actual lighting energy consumption is described in Section 2.1.2. The energy consumption under DLS can be calculated using Eq. (S10).

(S10)

where represents the electricity consumption for lighting per minute per household; and represent lighting minutes per day on weekdays and weekends, which are determined by the length of day and night and working and living time; details are shown in **Supplementary Table 13**; and and refer to weekdays and weekends in a year.

**Supplementary Table 13** Lighting time of weekdays and weekends

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Province | Lighting time of weekdays (min/day) | Lighting time of weekends (min/day) | Province | Lighting time of weekdays (min/day) | Lighting time of weekends (min/day) |
| Heilongjiang | 281 | 221 | Henan | 243 | 183 |
| Jilin | 283 | 223 | Hubei | 248 | 188 |
| Liaoning | 277 | 217 | Hunan | 244 | 184 |
| Inner Mongolia | 231 | 171 | Guangxi | 287 | 167 |
| Beijing | 251 | 191 | Guangdong | 247 | 187 |
| Tianjin | 254 | 194 | Chongqing | 217 | 157 |
| Hebei | 244 | 184 | Guizhou | 219 | 159 |
| Shandong | 255 | 195 | Yunnan | 204 | 144 |
| Shanxi | 235 | 175 | Sichuan | 207 | 147 |
| Jiangsu | 265 | 205 | Shaanxi | 225 | 165 |
| Anhui | 254 | 194 | Ningxia | 211 | 151 |
| Shanghai | 276 | 216 | Gansu | 203 | 143 |
| Zhejiang | 272 | 212 | Qinghai | 194 | 134 |
| Fujian | 270 | 210 | Xinjiang | 162 | 162 |
| Jiangxi | 255 | 195 | Hainan | 236 | 176 |

(4) Electric appliance. Based on the setting of DLS in **Supplementary Table 7**, the energy consumption of TV, refrigerators, and phones in each province for the DLS scenario can be calculated using Eq. (S11-S13). The energy consumption of electronic equipment in each province () can be obtained by summing up , and .

(S11)

(S12)

(S13)

where is the population of each province; denotes electricity consumption per year; represents power consumption per day.

* + 1. **Cooking**

The actual energy consumption for cooking () is calculated by Eq. (S14).

(S14)

where is the cooking energy consumption excluding energy waste and and represent the proportion and efficiency of different fuels, respectively (**Supplementary Table 9**).

The energy consumption of cooking in DLS) is calculated by Eq. (S15).

（S15）

where and are the proportions of electricity and gas used for cooking for the DLS scenario; and represent the efficiency of electricity and gas.

* 1. **Indirect energy consumption**
     1. **Extended input–output of the environment**

The extended input–output method is a combination of environmental indicators and the input–output method, which can calculate the impact of the entire economic activity on the environment and the indirect impact implied by the economic activity between industrial sectors. The environmental indicators in this paper refer to energy consumption. First, we calculate the direct energy intensity () using Eq. (S16). Then, we calculate the direct consumption coefficient matrix (A), which is composed of the direct consumption coefficient () by Eq. (S17). On the basis of A, we calculate the Leontief inverse by Eq. (S18), which shows the direct and indirect monetary inputs across the supply chain required to produce one monetary unit by each industry. Finally, we calculate indirect energy consumption due to residential final consumption in a sector by Eq. (S19).

(S16)

(S17)

(S18)

(S19)

where is the output of sector j and represents the column vector of residential final consumption in sector i. The input–output table used in this study contains 30 sectors and 30 provinces in China, which is obtained by combining China's multiregional input–output table for 42 sectors and the table of energy consumption of 46 sectors (). The final consumption sectors corresponding to each consumption category in this study are shown in **Supplementary Table 14**.

The indirect energy consumption coefficient (, j=f,y,t,e, cw,h,k,g) is used to calculate indirect energy consumption for each category of the DLS, and it is calculated by dividing the actual indirect energy consumption by a certain actual indicator. For each consumption category, this indicator is different, and the specific calculation is Section 2.2.2~2.2.9.

**Supplementary Table 14** Final consumption sectors by consumption categories

|  |  |
| --- | --- |
| Consumption categories | Final consumption sectors |
| Food | Food and tobacco |
| Clothing | Textiles, garments, shoes, hats, leather, down and their products |
| Transportation | Transport, storage, postal & telecommunications services |
| Housing | Electric power and heat production and suppl  Coal mining and dressing |
| Water | Water production and supply sector |
| Health care | Health and social work |
| Education | Others |
| Cooking | Electric power and heat production and suppl  Coal mining and dressing |

* + 1. **Food**

The energy consumption for the DLS is calculated as follows: First, Eq. (S20) is used to calculate the food energy consumption coefficient (). Next, the calorie consumption of each province under DLS() is calculated by Eq. (S21). Finally, the energy consumption for the DLS scenario of each province () can be obtained using Eq. (S22).

(S20)

(S21)

(S22)

where is the actual calorie consumption of residents per year; and represent the daily calorie consumption by men and women of all ages; and and are the populations of men and women by the age of each province (*China Statistical Yearbook*).

* + 1. **Clothing**

In terms of energy consumption for the DLS, the indirect energy consumption coefficient of clothing () is calculated as Eq. (S23). The weight of clothing needs in each province for the DLS () is then obtained using Eq. (S24). The energy consumption of each province for the DLS () can be calculated using Eq. (S25).

(S23)

(S24)

(S25)

where is the actual weight of clothes needed in the whole country; , and indicate the population of men, women and children corresponding to the temperature zone.

* + 1. **Transportation**

The final consumption of the transport, storage, postal & telecommunications services sector is much larger than that of transportation. In transportation, the final consumption of residents is based on the final consumption of residential transportation in each province, and the actual direct energy consumption of transportation is divided by the calorific value and then multiplied by the fuel price. The prices and calorific value of fuels are shown in **Supplementary Table 15**.

**Supplementary Table 15** The prices and calorific value of various fuels

|  |  |  |
| --- | --- | --- |
| Type of fuel | Calorific value(kJ/kg) | Price/tn |
| Diesel oil | 42652 | 6194.71 |
| Petrol | 43070 | 7172.94 |
| Jet fuel | 43070 | 3492.42 |

The energy consumption for the DLS scenario is obtained using Eq. (S26), by first calculating the indirect energy consumption coefficient for transportation () by Eq. (S27).

(S26)

(S27)

* + 1. **Housing**

Energy consumption for the DLS () is calculated using Eq. (S30), in which the indirect energy consumption coefficients for electricity and coal (、) are first obtained using Eq. (S28-S29).

(S28)

(S29)

(S30)

where and represent direct electricity, heat and coal consumption for housing for the DLS scenario for residents in each province.

* + 1. **Water**

To calculate energy consumption for the DLS (), Eq. (S31) is first used to calculate the indirect energy consumption coefficient of water (). The water consumption of residents in each province for the DLS () is then calculated, as shown in Eq. (S32). Finally, energy consumption by province is calculated for the DLS scenario by Eq. (S33).

(S31)

(S32)

(S33)

is the actual annual water consumption of national residents.

* + 1. **Health care**

Energy consumption for the DLS () is calculated using Eq. (S34-S35).

(S34)

(S35)

where represents the national-wide health care expenditure of residents per year and is the health care expenditure for the DLS of each province.

* + 1. **Education**

Since the final residential consumption of other sectors is much larger than that of education, it is replaced by education consumption here. Based on the indirect energy consumption coefficient () for education that is calculated using Eq. (S36), the energy consumption for the DLS () by province. can be calculated by Eq. (S37).

(S36)

(S37)

where denotes educational expenditure per year in China and is educational expenditure for the DLS scenario by province.

* + 1. **Cooking**

First, the indirect energy consumption coefficient () for gas is calculated using Eq. (S38). Then, the actual energy consumption of residents in each province is calculated using Eq. (S39).

(S38)

(S39)

where represents indirect energy consumption using gas by residents; is residential direct gas energy consumption; and , and are the direct energy consumption of electricity, gas and coal for actual cooking by residents.

The energy consumption for the DLS () is calculated by Eq. (S40).

(S40)

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