Chapter 4
Guangdong Carbon Emissions Status Quo and Main Characteristics

Guangdong energy consumption mix—dominated by fossil fuels—has generated high level of carbon emissions. The statistics revealed that aggregate energy consumption had been increasing year by year, and the evolution process could be split into three stages during 1995–2012. In Stage I (1995–2002), aggregate energy consumption increased with an AAGR at 6%. During this period, Guangdong economy grew at a slow pace, and consumption of coal, petroleum, and electricity achieved at an AAGR at 5, 7, and 14%, respectively. In Stage II (2003–2008), aggregate energy consumption grew with an AAGR at 12%, while GDP reached an AAGR at 14% (at 2005 constant prices), and the IVA rose with an AAGR at 20%, the consumption of coal, petroleum, and electricity presented an AAGR at 12, 9, and 22%, respectively. There was robust energy demand from industrial sectors in this stage, which led to the electricity demand over the supply. Though the total capacity of power generation expanded 52% during this period, newly added coal-fired power plants were not enough to satisfy the shortage. Thus, electricity imported from western China sharply ascended from 21.3 TW h in 2003 to 92.8 TW h in 2008. In Stage III (2009–2012), aggregate energy consumption dropped by 10% annually [1, 2]. Due to the impacts of the global financial crisis at the end of 2018 as well as domestic economic factors like the appreciation of RMB, GDP of Guangdong slowed down with an AAGR at 12%. Provincial export-oriented manufacturing sectors, which concentrated in the Pearl River Delta, were severely stricken. As a result, energy consumption in industrial sectors began to decrease. The AAGR of coal, petroleum and electricity consumption dropped to 10, 7, and 11%, respectively. Generally, Guangdong aggregate energy consumption reached 263 Mtce in 2012, accounting for 7.7% of total energy consumption in China.

This chapter will review the changes of Guangdong energy consumption patterns over 1995–2012, and analyze the characteristic of energy consumption of Guangdong province, including: carbon emission flow, emissions structure, carbon emission intensity, per capita emissions, emissions feature of electricity generation, emissions from energy consumption, and driving forces of carbon emissions.

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4.1 Guangdong Aggregate Energy Consumption Mix

Guangdong aggregate energy consumption, by maintaining an upward trend over 1995–2012 (see Fig. 4.1), reached 263 Mtce in 2012, accounting for 7.7% of China total energy consumption [2].

4.1.1 Guangdong Aggregate Energy Consumption and Spatial Distribution

The total energy consumption per unit GDP (TEC/GDP) across Guangdong maintained a downward trend over 2005–2011, i.e., the TEC/GDP of the entire province fell from 0.794 to 0.640 tce/10^4 yuan, dropping by an average of 3.53% annually. On a national scale, Beijing had the lowest TEC/GDP at 0.549 tce per 10,000 yuan in 2011, accounting for 62–45% of the national average. Ningxia had the highest TEC/GDP at 3.497 tce per 10,000 yuan in 2011. Guangdong had a fairly low TEC/GDP. Among all Chinese provinces, Guangdong was the only one that ranked second to Beijing, indicating that the energy-based economy and technologies of Guangdong were ranking at a relatively high level. However, owing to varied industrial structure and technical strength in different areas, the TEC/GDP

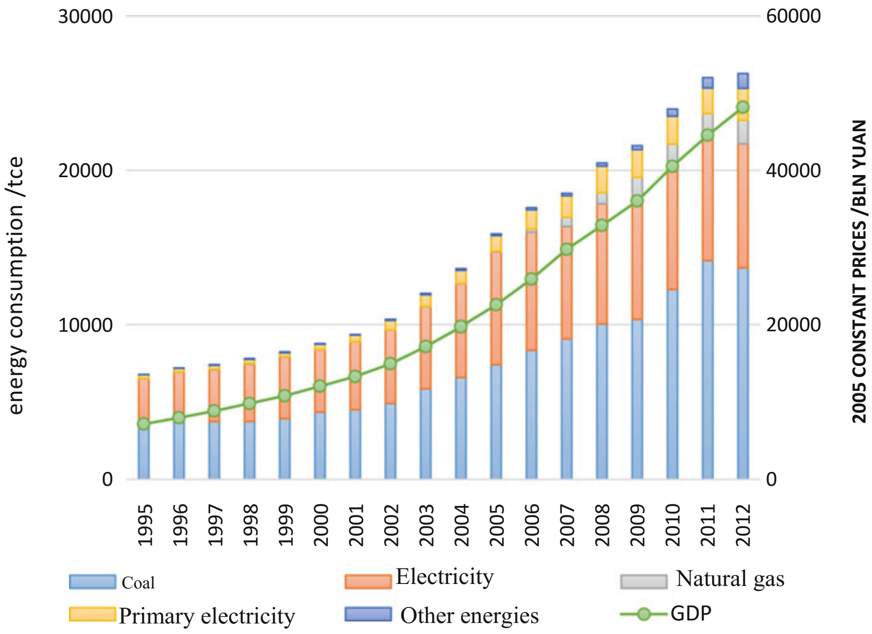

Fig. 4.1 Trends in Guangdong aggregate energy consumption and GDP growth in 1995–2012

of Guangdong varied greatly among different areas. Among the province's four major areas (see Table 4.1), the developed Pearl River Delta had energy use efficiency significantly above the other areas. The delta-based Shenzhen City had TEC/GDP no more than 0.5 tce/10^4 yuan, in contrast, Shaoguan in north Guangdong had the highest TEC/GDP, which was three times or more above Shenzhen [1, 3, 4].

With a view to TEC/GDP spatial distribution in Guangdong, in 2005, only two cities (Shenzhen and Shanwei) had a TEC/GDP lower than 0.6 tce/10,000 yuan; 13 cities were in range of 0.6–1.2 tce/10,000 yuan; 5 cities in range of 1.2–1.8 tce/10,000 yuan; only Shaoguan above 1.8 tce/10,000 yuan. In 2011, 5 cities (Shenzhen, Shanwei, Guangzhou, Zhuhai, and Shantou) had a TEC/GDP lower than 0.6 tce/10,000 yuan; 13 cities were in range of 0.6–1.2 tce/10,000 yuan; 3 cities in range of 1.2–1.8 tce/10,000 yuan; no city was above 1.8 tce/10,000 yuan.

Table 4.1 Guangdong TEC/GDP in 2005–2011 (Unit: tce per 10,000 yuan)

		2005	2006	2007	2008	2009	2010	2011
National		**1.28**	**1.24**	**1.18**	**1.12**	**1.08**	**1.03**	**1.01**
Beijing		**0.792**	**0.760**	**0.714**	**0.662**	**0.606**	**0.582**	**0.549**
Ningxia		**4.140**	**4.099**	**3.954**	**3.686**	**3.454**	**3.308**	**3.497**
Guangdong		**0.794**	**0.771**	**0.747**	**0.715**	**0.684**	**0.664**	**0.640**
Pearl River Delta	Guangzhou	0.782	0.746	0.713	0.680	0.651	0.621	0.590
	Shenzhen	0.593	0.576	0.560	0.544	0.529	0.513	0.490
	Zhuhai	0.659	0.640	0.624	0.603	0.581	0.560	0.536
	Foshan	0.888	0.848	0.811	0.746	0.694	0.664	0.637
	Dongguan	0.864	0.822	0.778	0.738	0.705	0.691	0.658
	Zhongshan	0.779	0.738	0.701	0.673	0.646	0.636	0.610
	Jiangmen	0.872	0.865	0.833	0.777	0.732	0.715	0.688
	Zhaoqing	0.988	0.958	0.919	0.887	0.844	0.823	0.793
	Huizhou	0.856	0.976	1.016	0.956	0.947	0.892	0.856
North (mountainous area)	Shaoguan	2.140	2.038	1.913	1.819	1.737	1.710	1.490
	Heyuan	0.962	0.897	0.884	0.840	0.809	0.800	0.771
	Meizhou	1.433	1.398	1.333	1.279	1.229	1.189	1.137
	Qingyuan	1.734	1.695	1.633	1.540	1.481	1.452	1.394
	Yunfu	1.525	1.436	1.389	1.338	1.294	1.274	1.228
West	Yangjiang	0.869	0.795	0.763	0.736	0.709	0.702	0.677
	Zhanjiang	0.738	0.710	0.682	0.659	0.641	0.639	0.616
	Maoming	1.332	1.282	1.256	1.190	1.146	1.097	1.055
East	Chaozhou	1.469	1.417	1.368	1.321	1.274	1.232	1.186
	Jieyang	1.029	0.973	0.940	0.902	0.874	0.855	0.819
	Shantou	0.692	0.662	0.648	0.632	0.608	0.588	0.567
	Shanwei	0.579	0.570	0.557	0.559	0.528	0.517	0.497

Note The TEC/GDP is calculated at 2005 constant prices

Source China Statistical Yearbook 2012, Guangdong Energy Statistics 2001–2010 and Guangdong Statistical Yearbook 2012

In terms of geographical distribution, the cities with a relatively high TEC/GDP are concentrated in the northern and eastern areas of Guangdong, while the cities with a lower TEC/GDP are located in the Pearl River Delta and coastal area which are fairly developed.

4.1.2 Elasticity Coefficient of Energy Consumption

Elasticity Coefficient of Energy Consumption (ECEC) is the percentage change in energy consumption to achieve one percent change in national GDP at constant prices. It is an indicator to demonstrate the relation between energy consumption and GDP growth. A smaller ECEC represents less dependence of GDP growth on energy consumption. Figure 4.2 shows that Guangdong ECEC had been fluctuating over 1995–2012 with both GDP and energy consumption maintaining positive growth in each year; thus, ECEC could remain as a positive value. There had been ECEC >1 in 2003, 2005, and 2008, showing Guangdong GDP growth was notably lower than energy consumption growth. There was ECE <1 in the most part of this period, indicating that although Guangdong kept developing its socio-economy, its energy consumption was increasing at a slower pace, but the aggregate energy consumption did not show any downward momentum [1, 2].

After comparing the ECEC between developed countries/regions and Guangdong (Table 4.2), we've found out that Guangdong had the highest growth rate in both GDP and energy consumption over 1995–2012. Guangdong had an ECEC slightly above the national average. In contrast to the US, Germany, UK, and Japan with a low or negative ECEC over 1995–2012, the ECEC of Guangdong and China at large remained high, demonstrating that the Chinese economy (including

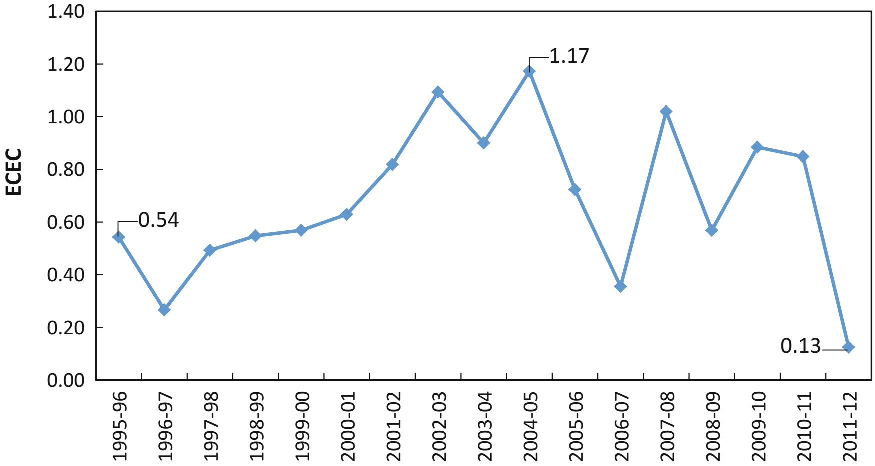

Fig. 4.2 Guangdong ECEC in 1995–2012

Table 4.2 ECEC in certain countries/regions in 1995–2012

Country/Region	GDP growth (%)	Energy consumption growth (%)	ECEC
Mainland China (1)	382	176	0.46
Guangdong (1)	571	286	0.50
US (2)	52	3	0.06
Germany (2)	26	−9	−0.34
UK (2)	43	−11	−0.25
Japan (2)	14	−9	−0.66
S. Korea (2)	111	82	0.74
Hongkong (2)	81	39	0.49

Source (1) China Energy Statistical Yearbook 1996–2013; (2) the World Bank

Guangdong) was growing at a faster pace though started later, registering a GDP growth rate significantly above the growth rate of energy consumption, hence ECEC <1. However, in contrast to Germany, UK, and Japan where the energy demand kept negative growth, Guangdong had an actively increasing energy demand with a positive ECEC.

4.1.3 Energy Consumption Intensity

Although Guangdong aggregate energy consumption kept increasing over 1995–2012, the Energy Consumption Intensity (ECI) dropped from 0.95 tce per 10,000 yuan in 1995 to 0.55 tce per 10,000 yuan in 2012 (calculated at 2005 constant prices), registering a decrease rate at 43%. In 2012, the ECI of Guangdong was lower by 41% than the national average, but still higher than that of developed countries/regions like US, Germany, UK, Japan, South Korea, and Hongkong (see Fig. 4.3). However, with a view to ECI variation trend over 1995–2012, the ECI of Guangdong and China at large, respectively, dropped by 43 and 45%, higher than such decrease between 14 and 38% in US, Germany, UK, Japan, South Korea, and Hongkong [1, 2, 5].

4.1.4 Energy Consumption Per Capita

In 2012, the GDP (at current prices), population and aggregate energy consumption of Guangdong, respectively, accounted for 11.0, 7.8 and 7.7% of the national total. Along with constantly increasing GDP per capita, the energy consumption per capita (ECpc) of Guangdong rose from 0.92 tce in 1995 to 2.48 tce in 2012, registering a robust growth rate at 169% (see Fig. 4.4). In 2012, Guangdong ECpc was 17% below the national average level, and respectively, lower by 74, 55, 43,

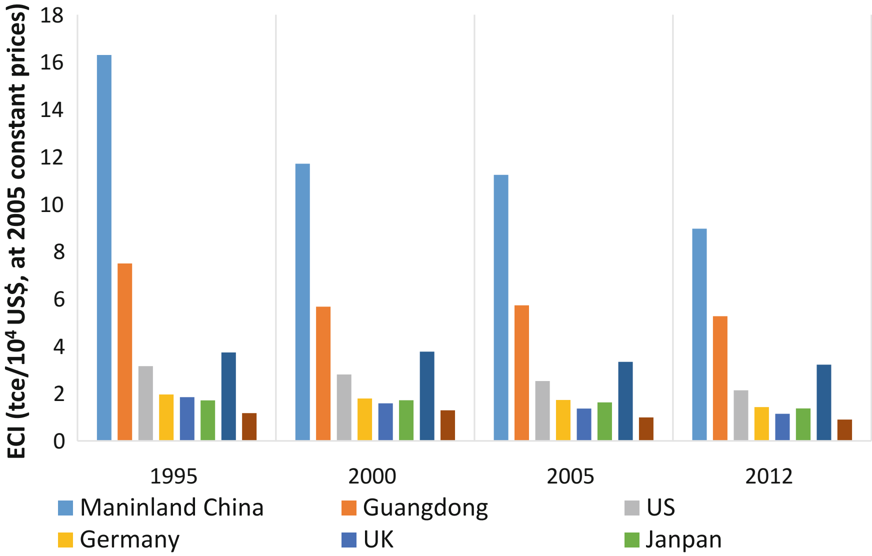

Fig. 4.3 ECI comparison in 1995–2012

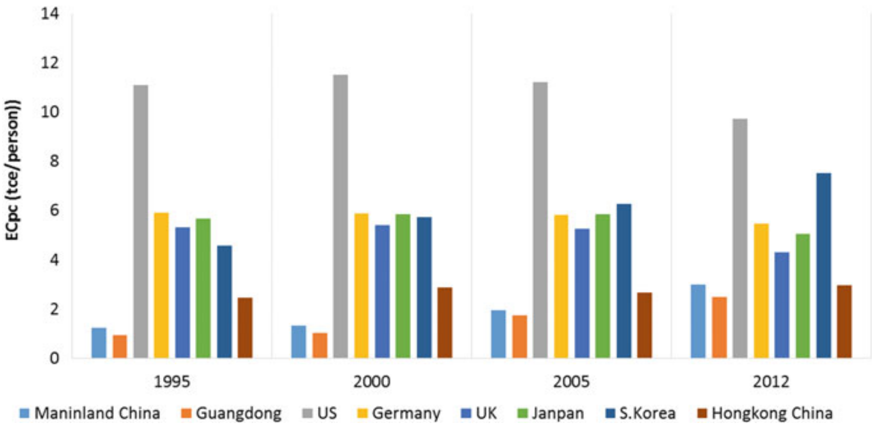

Fig. 4.4 ECpc comparison in 1995–2012

51, 67 and 16% in contrast to US, Germany, UK, Japan, South Korea, and Hongkong. However, with a view to ECpc growth rate, Guangdong ECpc growth rate was higher by 27% than the national average level over 1995–2012. In the meanwhile, the ECpc growth rate of US, Germany, UK, and Japan dropped by 12, 7, 19, and 11%, respectively. The ECpc growth rate of South Korea and Hongkong rose by 64% with 20%, respectively, yet far below that of Guangdong [1, 2, 5].

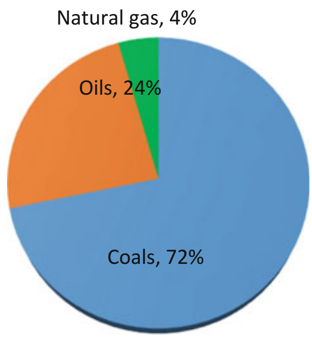

Fig. 4.5 Guangdong aggregate carbon emissions breakdown by fuel type in 2012. *Note* Guangdong aggregate carbon emissions reached 573 $MtCO_{2e}$ in 2012

4.2 Guangdong Aggregate Carbon Emissions and Carbon Flow

In light of *Guangdong Statistical Yearbook 2013*, and calculating method recommended by IEA and U.S.A, [6, 7] Guangdong aggregate carbon emissions reached 573 $MtCO_{2e}$ in 2012; among them, the emissions from consumption of coal, oil, and natural gas were, respectively, 411, 137, and 25 $MtCO_{2e}$. Their percentages in aggregate carbon emissions are shown in Fig. 4.5.

With a view to China's carbon emissions scale by province/region/municipality,[1] Guangdong was among the heavy emissions rank over 1995–2005, then joined in the ultra-heavy emissions rank since 2006. Of the emissions arising from production and livelihood, it was the emissions from the primary industry were decreasing amid moderate fluctuations, i.e., down from 1.46 tCO_{2e} in 1995 to 1.23 tCO_{2e} in 2011, registering an annual average decrease at 1.03%. The carbon emissions from the secondary and tertiary industries and from livelihood kept increasing, i.e., rising from 35.80 tCO_{2e}, 4.03 tCO_{2e} and 3.24 tCO_{2e} to 124.35 tCO_{2e}, 18.38 tCO_{2e} and 8.62 tCO_{2e}, with an AAGR at 8.09, 9.94 and 6.32%. Obviously, the secondary industry was the largest emitter in Guangdong with the percentage in aggregate emissions remaining in range of (81 ± 1)%. The tertiary industry was the second largest emitter in Guangdong with a share in aggregate emissions maintaining an upward trend (Fig. 4.6).

See the carbon flows of Guangdong in Fig. 4.7 [8], electricity production, which is based on energy conversion, was the largest emitter with carbon emissions of 264 $MtCO_{2e}$ in 2012, holding 46% of the provincial total emissions. The emissions from heat production reached 19 $MtCO_{2e}$, holding 3% of the provincial total emissions. After assigning the emissions from electricity and heat production to manufacturing sector—the largest emitter (holding 65%) at the end of final energy

[1]The Chinese carbon emissions scale are split into four classes: Class I (ultra-heavy emissions) with emissions larger than 1×10^8 t/year; Class II (heavy emissions) with emissions of (9999–3000) $\times 10^4$ t/year; Class III (general emissions) with emissions of (2999–1000) $\times 10^4$ t/year; Class IV (light emissions) with emissions at or below 999×10^4 t/year.

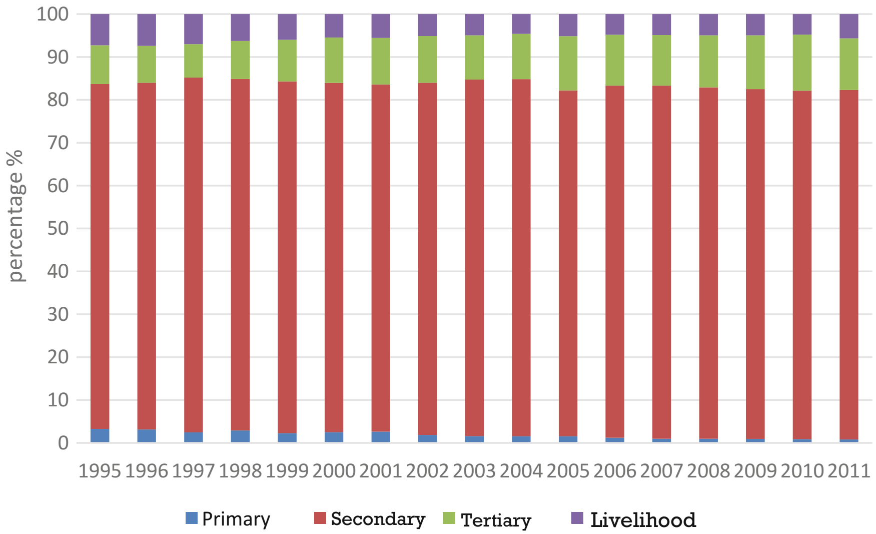

Fig. 4.6 Guangdong aggregate carbon emissions breakdown by emitting sources in 1995–2011

consumption, which was followed by transportation and storing sectors (11%); the combined emissions from the urban and rural residential consumption held 13%.

4.2.1 Characteristics of Carbon Emissions Composition

Guangdong's direct carbon emissions from all types of energy over 1995–2012 are shown in Fig. 4.8. During this period, the carbon emissions from energy consumption remained on the rise, which was attributed to mounting demand for various fossil fuels arising from the rapidly developing socio-economy. There used to be low consumption of natural gas in 1995; however, along with the operation of the receiving terminals and implementation of the "gas transmission from west China to east China", Guangdong began to consume more and more natural gas, which generated increasing carbon emissions. However, natural gas is a low-carbon energy with carbon emissions coefficient merely 56 and 72% of coal and petroleum. According to a rough estimation shows that replacing coal or petroleum consumption with natural gas is able to save carbon emissions by 44 and 28%.

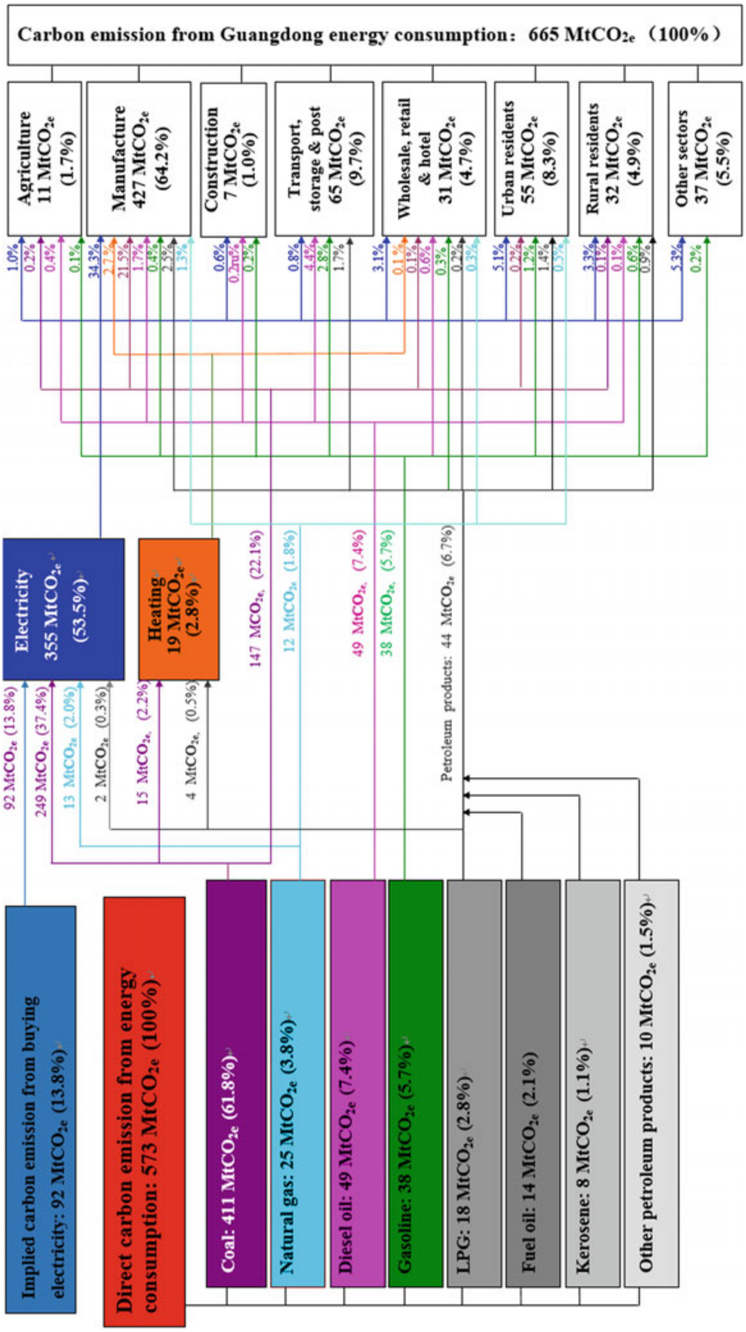

Fig. 4.7 Guangdong's carbon emission flows in 2012

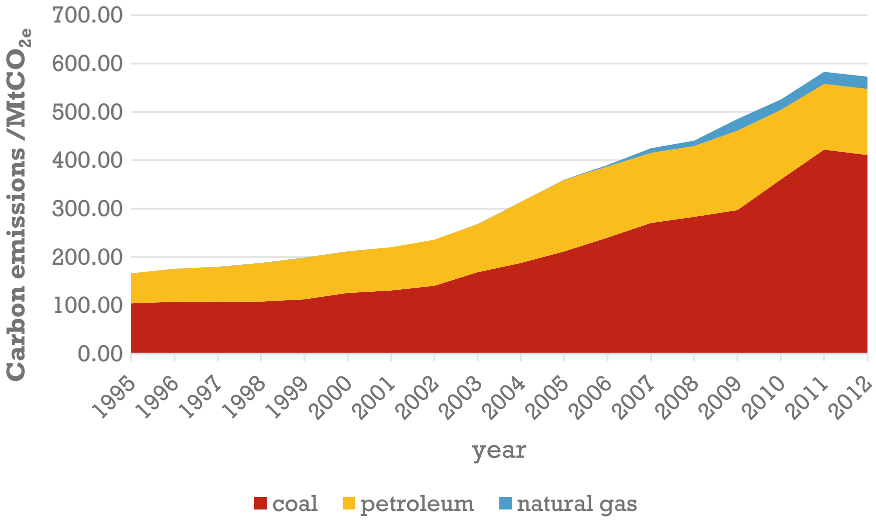

Fig. 4.8 Guangdong carbon emissions by energy type in 1995–2012

4.2.2 Carbon Intensity

Carbon intensity is a ratio between local aggregate carbon emissions and GDP. Quantified carbon intensity is able to reflect the dependence degree of economic growth on fossil energy consumption, it is closely related to local energy use efficiency and energy consumption mix. As shown in Fig. 4.9, both GDP and carbon emissions of Guangdong maintained an upward momentum over 1995–2012, with carbon intensity remaining at the downside, i.e., falling from

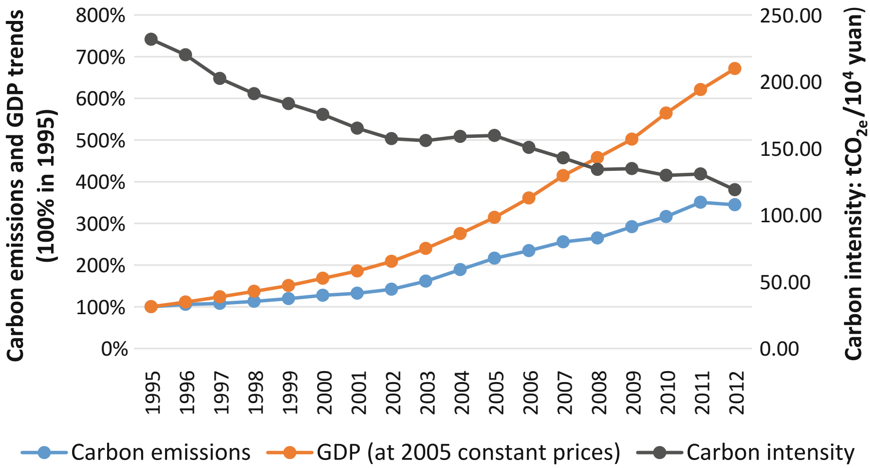

Fig. 4.9 Guangdong carbon intensity in 1995–2012

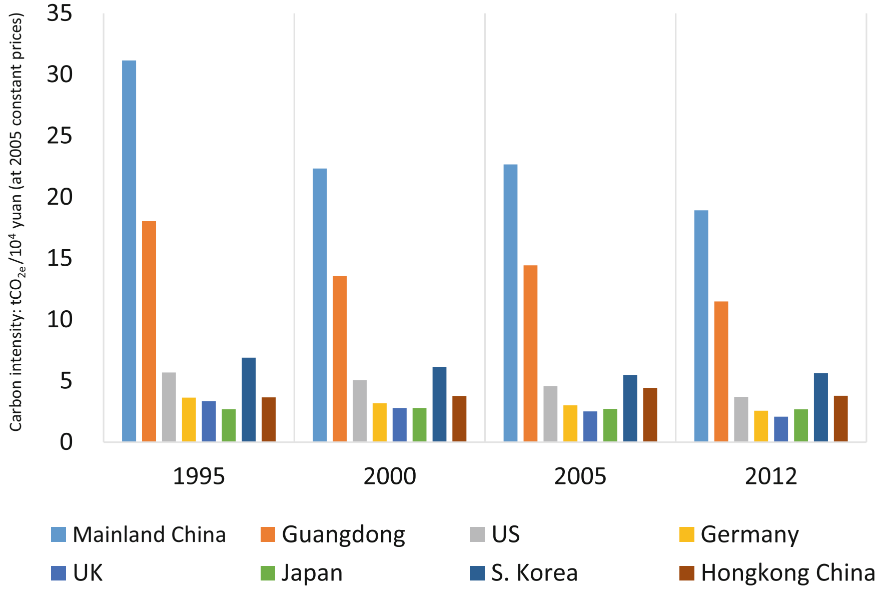

Fig. 4.10 Carbon intensity comparison between Guangdong and world major economies in. *Source* Despite the statistics about Guangdong, all the other data stem from US Energy Information Administration

2.32 tCO_{2e}/10,000 yuan in 1995 to 1.19 tCO_{2e}/10,000 yuan, dropping by an average of 4% annually.

As indicated in Fig. 4.10, Guangdong carbon intensity was lower by 65% than the national average level in 2012, but higher by 68, 78, 82, 77, 51, and 67% [5, 9] than US, Germany, UK, Japan, South Korea, and Hongkong, respectively. But with a view to the downward trend of carbon intensity, both Guangdong and China at large reduced carbon intensity by 37 and 39%, slightly higher than such drop in US (35%), Germany (30%), and UK (38%), and far above Japan (1%), and South Korea (18%), marking that Guangdong has achieved significant progress in raising energy use efficiency, energy conservation, and emissions reduction, and in upgrading socioeconomic development quality, yet there is still a long way to go for Guangdong to catch up with the advanced energy use efficiency in the European states and US.

4.2.3 Carbon Emissions Per Capita

Guangdong saw its population increase by 43% over 1995–2012, and reach 106 million in 2012. As shown in Fig. 4.11 the growth of Guangdong carbon emissions exceeded that of population, which resulted in a year-on-year increase in carbon emissions per capita (CEPC). In 2012, Guangdong CEPC reached 5.41 tCO_{2e}/person.

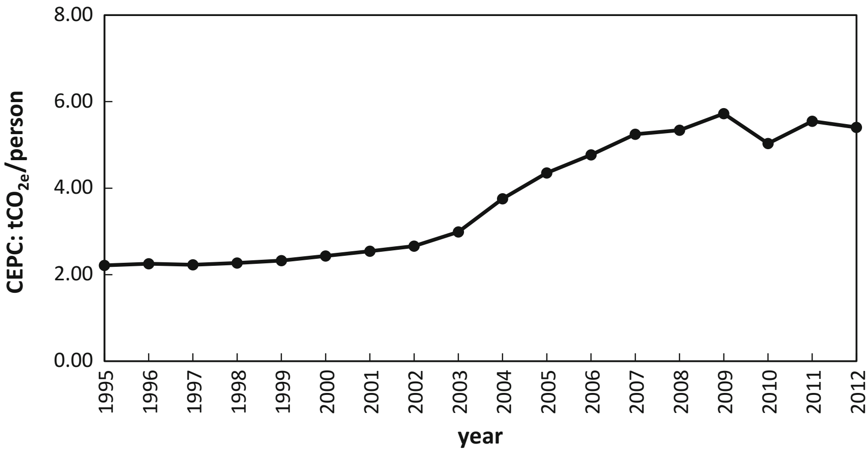

Fig. 4.11 Guangdong CEPC in 1995–2012

In 2012, the CEPC of Guangdong was 17% lower than the national average level, and remarkably lower than that of world major economies like US, Germany, UK, Japan, South Korea, and Hongkong. Over 1995–2012, the CEPC of Guangdong and China at large kept increasing, but the CEPC of US, Germany, and UK remained on the downside, falling by 16, 10, and 19%, respectively. The CEPC of Japan, South Korea, and Hongkong, though situated in Asia as Guangdong, was increasing slowly with a growth rate of 11, 55, and 61% [5, 9], respectively. Though the CEPC of Guangdong is currently lower than that of developed states/ regions in Europe and America, it has been increasing rapidly; moreover, the cardinal number of Guangdong population is large and remaining stable, and the provincial economy keeps sustainable growth, which makes control of carbon intensity an especially important task (Fig. 4.12).

4.2.4 Carbon Emissions from Electricity Production

In 2012, the total carbon emissions from electricity production of Guangdong reached 264 $MtCO_{2e}$, not counting into the indirect emissions from consumption of purchased electricity. Of the total emissions, the coal-based, natural gas-based, and petroleum-based electricity production accounted for 94.4, 4.9, and 0.6%, respectively. As shown in Fig. 4.13, total carbon emissions from electricity production were assigned to each consumption end based on their percentage of total electricity consumption, so as to identify the emissions from end users. Industrial sectors—the largest emitter—contributed to 64% of total carbon emissions from electricity production; while the combined emissions from urban and rural household consumption shared another 16%.

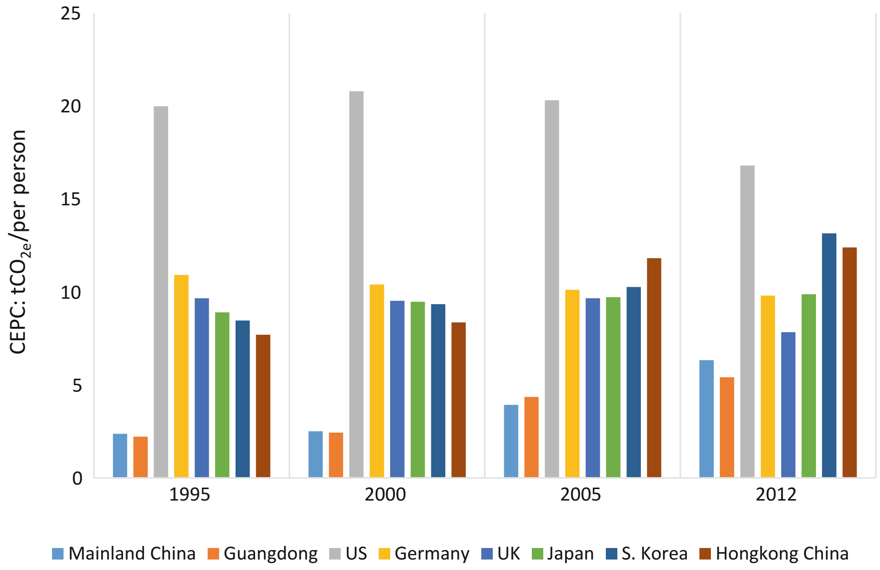

Fig. 4.12 CEPC comparison between Guangdong and world major economies in 1995–2012

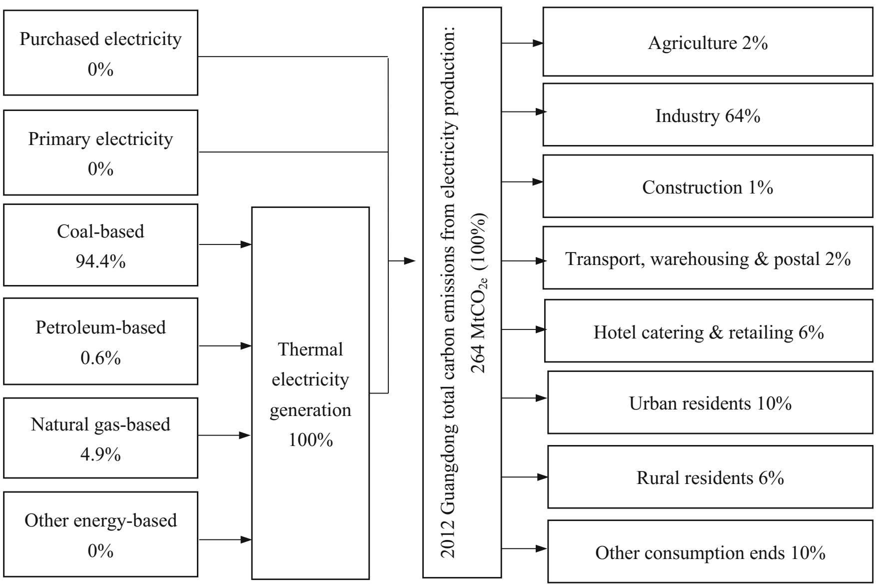

Fig. 4.13 Carbon flow comes from electricity production in Guangdong in 2012. *Note* The "primary electricity" is made up of the nuclear power, hydropower, and wind power produced within Guangdong

The characteristics related to energy consumption and carbon emissions from electricity generation of Guangdong could be analyzed by three stages, which are as follows:

Stage I (1995–2002): During this period, the economy of Guangdong was developing at a slow pace, with the energy consumption for electricity production rising at an AAGR of 14%. Of the total electricity, respective 60 and 27% were generated from coal-fired power plants and petroleum-fired power plants, 2% was from purchased electricity, and 11% was supplied by nuclear power, hydropower, and wind power together. The carbon emissions from Guangdong electricity production rose with an AAGR at 9%.

Stage II (2003–2008): During this period, the GDP of Guangdong was rising with an AAGR of 14% (calculated at 2005 constant prices), such growth of IVA was 20%, and the energy consumption for electricity production was increasing with an even higher AAGR of 22%. The coal-based installed capacity increased 52%. The share of coal-based electricity in total electricity output rose to 66%, the share of petroleum-based electricity dropped to 14% under the pressure from mounting generation cost and strict environmental protection, while the combined share of nuclear power, hydropower and wind power was 9%. In order to make up for the shortage in electricity demand, Guangdong increased electricity purchase from the project as "electricity transmission from west China to Guangdong", i.e., from 21.3 TWh in 2003 to 92.8 TWh in 2008. The share of purchased electricity in Guangdong total electricity output rose to 13%. Owing to the sharp increase in energy consumption for electricity production, and shrinking share of nuclear power, hydropower, and wind power, the carbon emissions from Guangdong electricity production rose with an AAGR at 10% during this period.

Stage III (2009–2012): Under the impact from several economic factors at the end of 1998 like the global financial storm and appreciation of RMB, the GDP of Guangdong was increasing with a lower AAGR at 10% during this period. Such growth of the electricity consumption in industrial sectors dropped from 13% over 2003–2008 to 7%. Such growth of the energy consumption for electricity production fell to 7%. Of the total electricity output, the share of electricity from coal-fired generators rose to 72%. Owing to sharply increasing generation cost of petroleum-fired power plants and intensified efforts in air pollution control, small thermal power plants with a capacity of about 12.1 GW were shut down during 2006–2010, the share of petroleum-based electricity dropped to 1%. Along with Shenzhen Dapeng LNG Receiving Terminal stating to operate in 2006, the share of electricity from natural gas-fired power plants achieved to 7%. The amount of electricity purchased from other provinces based on the program of "electricity transmission from west China to Guangdong" steadily ascended, and its share in total electricity supply increased to 11% consequently. Meanwhile, electricity supplied by nuclear power, hydropower, and wind power together took account for rest 9%. Overall, the carbon emissions from power sectors increased with an AAGR of 8% in this stage (Fig. 4.14).

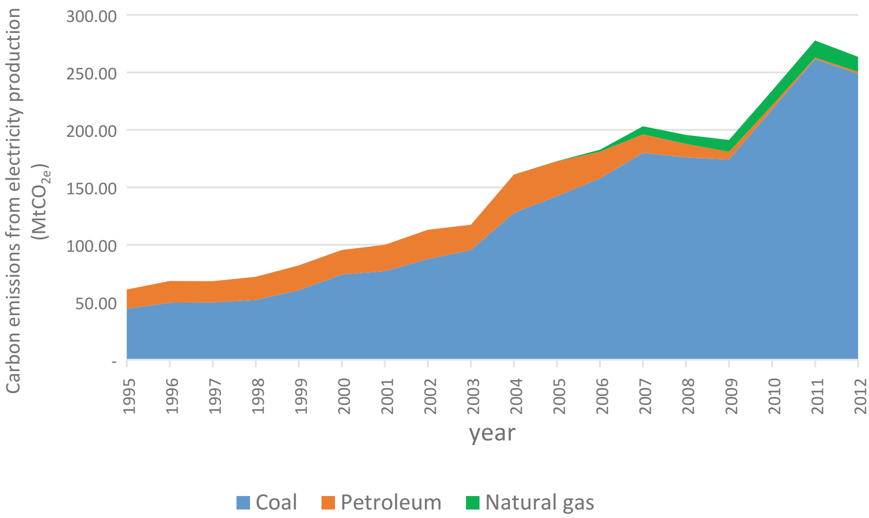

Fig. 4.14 Carbon emissions from Guangdong electricity production by different energies in 1995–2012

4.3 Decomposition of the Driving Force for Carbon Emissions

In order to analyze the characteristic carbon emissions from end users, emissions from electricity and heat generation were then allocated to respective end users based on energy consumption percentage. Overall, the aggregate carbon emissions of Guangdong from energy consumption rose from 166 $MtCO_{2e}$ in 1995 to 573 $MtCO_{2e}$ in 2012, and emissions from all end users had kept an upward trend (see Fig. 4.15).

In the percentage of emissions, manufacturing sector was ranking the top (64–68%) over 1995–2012. During this period, the percentage of emissions from transport, warehousing and postal sectors, wholesale-retail sectors, and other service sectors rose 3, 1, and 2%, respectively; such percentage of agriculture, animal husbandry, and fishery sectors dropped 2%.

With a view to the growth rate of emissions, the AAGR of the emissions from transport, warehousing and postal sectors, wholesale-retail sectors, and other service sectors was 10%, higher than that of the provincial total emissions (8%). The manufacturing sector, which belongs to the secondary industry, is the largest emitting source. The AAGR of carbon emissions from manufacturing sector leveled off the growth of provincial total emissions. In contrast, such growth of agriculture, animal husbandry and fishery sectors, which belong to the primary industry, was merely 2%. Such situation is mainly attributed to the industry restructuring in Guangdong, i.e., the focus is shifting from the primary industry to tertiary industry,

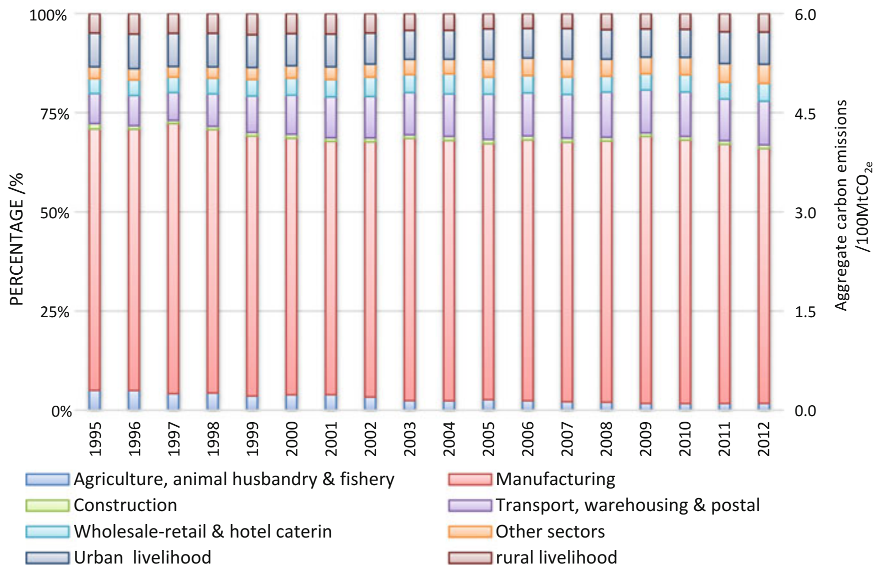

Fig. 4.15 Percentage of carbon emissions of Guangdong by consumption end in 1995–2012

yet the adjustment to the secondary industry is limited; in other words, the secondary industry remains as the predominant emitting source.

With a view to the increments in carbon emissions, the aggregate carbon emissions of Guangdong increased 407 $MtCO_{2e}$ over 1995–2012. Of the total increments, 64% was contributed by the manufacturing sector, 12% were from transport, warehousing, and postal sectors, and 13% from urban and rural livelihood.

In order to dissect the driving forces for carbon emissions from energy consumption end, we use LMDI approach to interpret the Kaya and Johan models that represent development of industrial sectors, and the ImPACT model indicating development of population and society, so as to analyze the 10 driving forces which are distributed in production sector (i.e., economic activities, industry structure, energy intensity, energy consumption mix, and emissions coefficient of energy consumption) and in people's livelihood (i.e., population growth, urbanization level, degree of prosperity, energy consumption mix, and emissions coefficient of energy consumption).

Of the total the increments in carbon emissions of Guangdong over 1995–2012, 64% was contributed by manufacturing sectors; 2% by "transport, warehousing and postal sectors"; 8 and 5% by urban and rural livelihood, respectively; 6, 5, and 1% by the other service sectors, wholesale-retail and hotel catering sectors and construction sector, respectively (see Fig. 4.16).

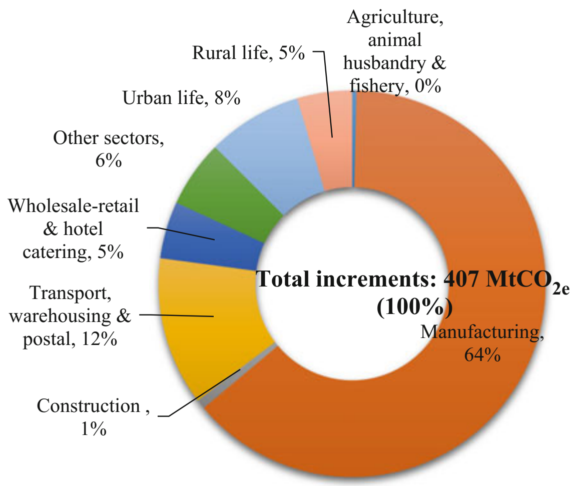

Fig. 4.16 Breakdown of Guangdong carbon emissions increments by energy end-use in 1995–2012

4.3.1 Driving Force in Carbon Emissions from Production End

The increments in carbon emissions from production end[2] reached 356 $MtCO_{2e}$ over 1995–2012, accounting for 87% of the total increments. The carbon emissions from production end were increasing at a varied pace over 1995–2012 (see Fig. 4.17). The increments over 2003–2009 were ever larger and averaging at 32 $MtCO_{2e}$ per year, which was 55% higher than the average increments over 1995–2012. It was attributed to the robust development of the export-oriented economy of Guangdong since China's accession to the WTO, the production scale of all economic sectors began to expand, and the carbon emissions from energy consumption were increasing at a fast pace, such increments topped at 42 $MtCO_{2e}$ over 2008–2009.

With a view to driving force, it is the economic output that mainly drives up the growth of carbon emissions from production end. Despite of the 2011–2012 period, the driving force had exerted a positive effect and contributed 152% of the increments over 1995–2012. Energy intensity is a major driving force for cutting back the increments in emissions (cutting 42% over 1995–2012). Energy structure, industry structure, and emissions factor of the production end were of moderate effect on carbon emissions over 1995–2012, and fairly fluctuating; they contributed 6, 4 and −11% to the increments in carbon emissions over 1995–2012.

[2]"Production end" refers to agriculture, manufacturing and catering sectors despite of the energy consumption for people's livelihood. The "consumption end" shown in the previous subsector is made up of both production sectors and people's livelihood. In this subsection, "production end" and "resident end" are cited to differentiate all production sectors and people's livelihood.

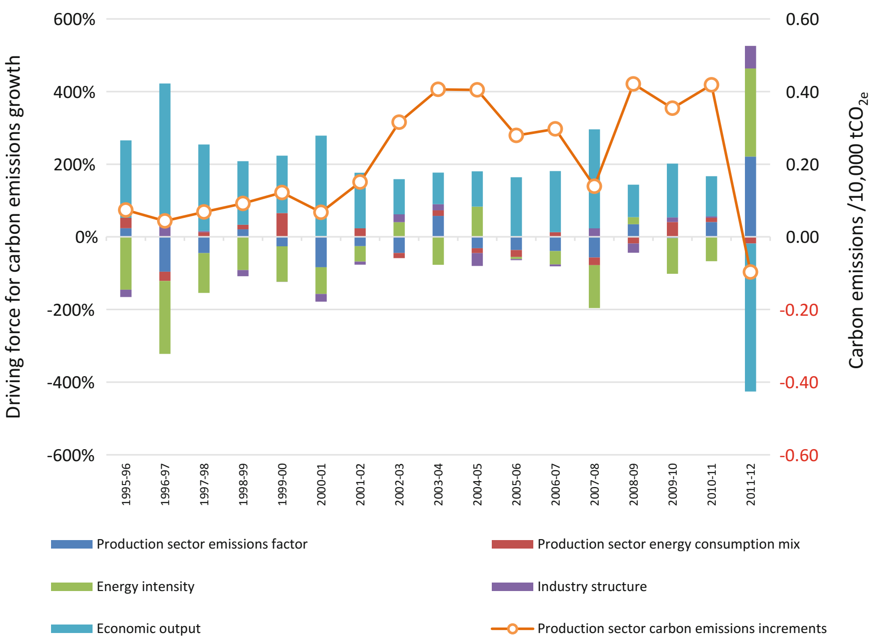

Fig. 4.17 Driving force for Guangdong carbon emissions growth in production end over 1995–2012

4.3.2 Driving Force in Carbon Emissions from Resident End

Over 1995–2012, the increments in carbon emissions from resident end reached 51 $MtCO_{2e}$, accounting for 13% of the total increments and registering a year-on-year increase. The annual average increments were as high as 5 $MtCO_{2e}$ over 2003–2011, far exceeding the increments of 1 $MtCO_{2e}$ over 1995–2002, because along with constantly developing economy and increasingly affluent life, the residents have more disposal income, and widely applied transport means and home appliances, which, in turn, increased carbon emissions. The increments topped at 15 $MtCO_{2e}$ over 2010–2011 (see Fig. 4.18).

Over 1995–2012, despite the expanding population size that exerted a positive role in driving up carbon emissions, all the other driving forces were fluctuating greatly. Overall, people's affluent life was the major driving force, contributing 76% of the increments over 1995–2012, followed by population size (26%), livelihood energy consumption mix (5%), and urbanization (4%). In addition, emissions factor—owing to optimized energy structure—slowed down increments in carbon emissions by 13%.

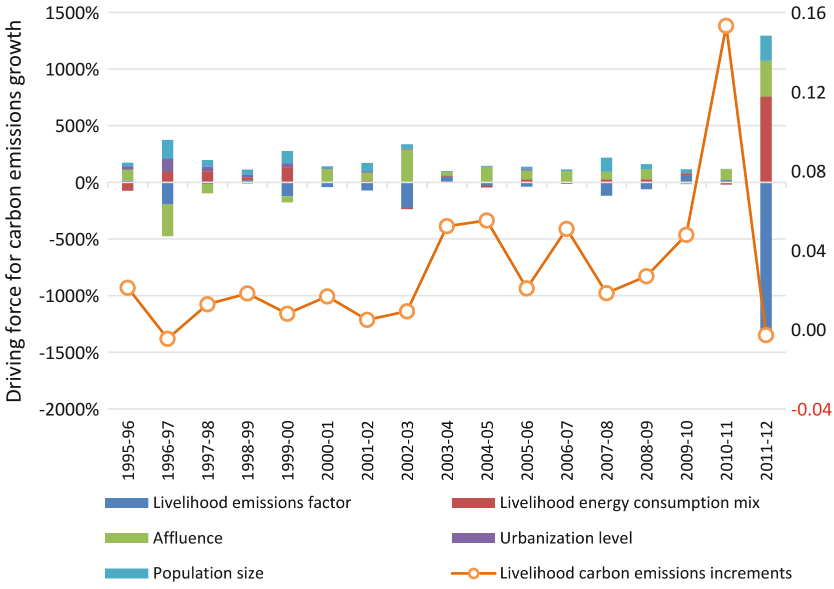

Fig. 4.18 Driving force for Guangdong carbon emissions growth in the resident end over 1995–2012

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