Structure of Fluctuations in Residential City Gas Sales Volume in Recent Years

Rino Hirose*
Economist, Economic and Statistical Analysis Group (ESA), Energy Data and Modelling Center (EDMC)

1. Introduction

City gas is an energy source used in households for water heating, air conditioning, and cooking. According to the FY2022 General Energy Statistics of Japan, 23% of the energy consumed in Japan's residential sector is city gas, highlighting the importance of city gas as an energy source for residential use.

This paper focuses on the sales volume of residential city gas and examines the qualitative and quantitative factors behind the fluctuations in sales volume.

2. Trends in Residential City Gas Sales Volume

Figure 1 shows the trends of city gas sales volume in the residential sector from 2016 to 2024 (Current Survey of Production Concerning Gas Industry). Residential city gas sales volume[1] was 388 PJ (10,192 million m^3) in 2016, 375 PJ (9,391 million m^3) in 2023, and 378 PJ (9,470 million m^3; estimated and calculated by the author for December 2024) in 2024. Focusing on the year-on-year rate of change, residential city gas sales volume fell by 1.9% in 2016, increased by 4.9% in 2017, and decreased by 3.2% in 2018. It increased for three consecutive years from 2019, which included a notable 2.3% increase in 2020, the year when the COVID-19 pandemic started. Thereafter, it decreased for two years running from 2022, and most recently, it is estimated to have risen by 0.8% in 2024. Residential city gas sales volume fell by 2.5% compared to 2016 and 8.1% compared to 2021, when residential city gas sales volume was at its highest over the past nine years. Although residential city gas sales volume recorded year-on-year increases in the short term, it has decreased slightly or remained largely unchanged at about 400 PJ since around FY2000.

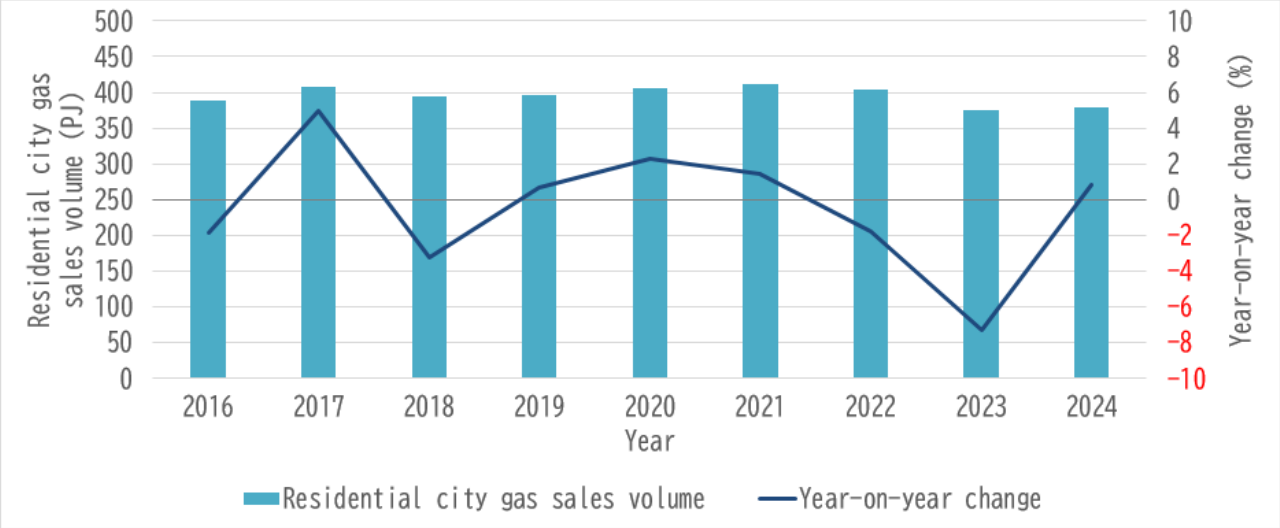

Figure 1 Trends of city gas sales volume in the residential sector in recent years
(Source: Estimated based on Current Survey of Production Concerning Gas Industry. The figure for December 2024 is an estimate.)

* The Institute of Energy Economics, Japan
[1] Converted at 1 m^3 = 39.964 MJ based on the Standard Calorific Value (General Energy Statistics of Japan) revised in 2020.

3. Relationship between Residential City Gas Sales Volume and Temperature

There is a significant relationship between temperature and residential city gas sales volume. According to the *EDMC Handbook of Japan's & World Energy & Economic Statistics* (2024), in FY2022, 66% of city gas consumption per household in the residential sector was used for water heating, 17% for space heating, and 17% for cooking use, while city gas was rarely used for space cooling homes. City gas for cooking use is less susceptible to being affected by temperature, while use for space heating and water heating are significantly affected by temperature (water temperature). Specifically, when temperatures are high, there is lower demand for water heating. Similarly, when temperatures are high in winter, demand for space heating is low. In other words, residential city gas sales volume generally decreases when average temperatures rise.

Figure 2 shows the relationship between average monthly temperature and average monthly residential city gas sales volume for the nine-year period from January 2016 to December 2024. The monthly average temperature was calculated by taking into account the effect of meter reading discrepancies[2] and calculating the monthly average temperature for each year by taking the average temperature of the previous month x 0.5 + the average temperature of the current month x 0.5 to determine the monthly average temperature for the nine-year period. We can infer that the residential city gas sales volume is closely related to temperature, based on data indicating that sales volume is lowest in summer and highest in winter, as much as four times higher than in the summer months. At the same time, we can also infer that residential city gas sales volume is higher in the first half of the year than in the second half of the year, even when temperatures are similar, for example, between March and December. This is likely due to the effect of changes in water temperature lagging behind air temperature.[3]

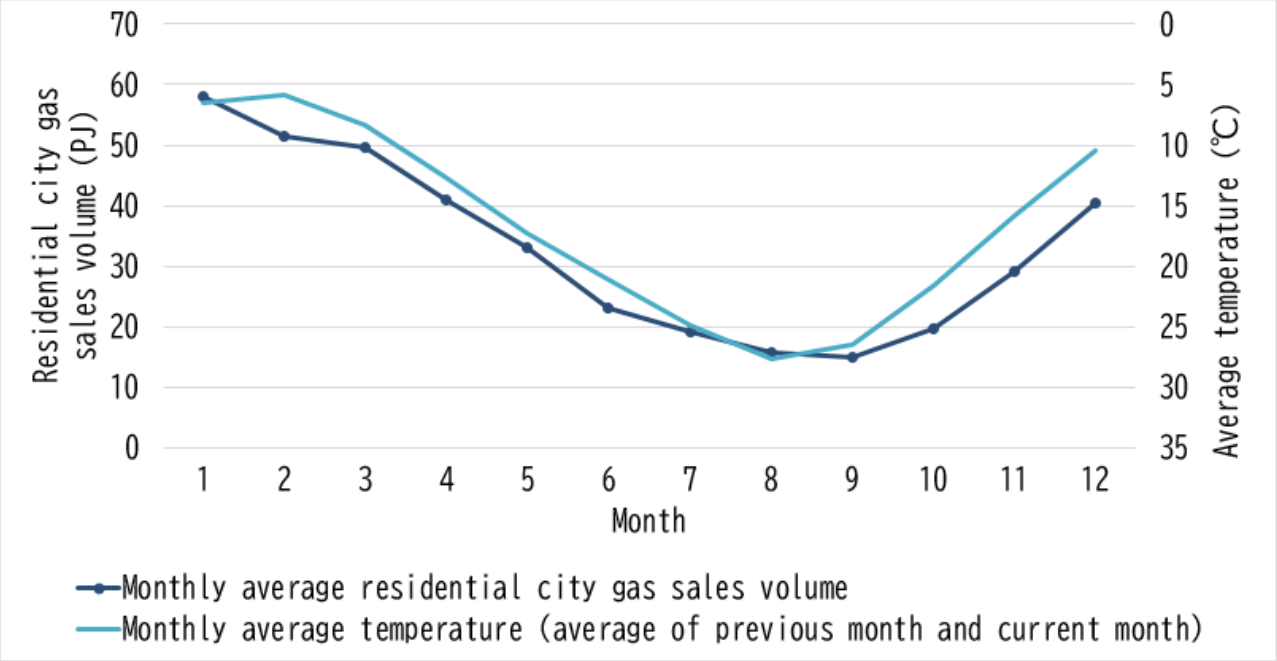

Figure 2 Relationship between average monthly temperatures and average monthly residential city gas sales volume
(Source: Estimated based on Current Survey of Production Concerning Gas Industry and Japan Meteorological Agency. The figure for December 2024 is an estimate.)

4. Contribution of Various Factors to Residential City Gas Sales Volume

In order to see not only the relationship of residential city gas sales volume with average temperatures, as examined earlier, but also its relationship with other factors, the factors contributing to fluctuations in residential city gas sales volume (monthly) were determined quantitatively. A multiple regression analysis was carried out using data from January 2016 to November 2024 to calculate the contribution of each factor.

The assumed factors used in this paper were temperature, the COVID-19 pandemic, time trends, number of assessed bills per

[2] Although remote meter reading is becoming increasingly widespread, meter readings taken by visiting households and checking the gas meter is still practiced in some areas. For this reason, the amount of gas used across months is included in the city gas sales volume (for example, the amount used in January is included in the sales volume for February).

[3] Water has a high specific heat capacity, which makes it difficult to heat up and cool down.

household,[4] number of households, number of days, and others. Gas price factors were also considered, but since multiple regression analysis did not yield economically meaningful values,[5] the decision was made not to address them explicitly in this paper.

Residential city gas sales volume fluctuates with the number of households, the number of assessed bills, and the number of days in the month,[6] and these relationships can be expressed by the following formula.

$$Residential\ city\ gas\ sales\ volume = \frac{Residential\ city\ gas\ sales\ volume}{No.of\ bills\ assessed\ \times\ no.of\ days} \times \frac{No.of\ bills\ assessed}{No.of\ households} \times No.of\ households \times No.of\ days$$

The daily average residential city gas sales volume per unit of bills assessed, which is calculated by dividing residential city gas sales volume by the number of bills assessed and the number of days in the month, can be further broken down by factors including temperature, the COVID-19 pandemic, time trends, and others. The temperature factor corresponds to the monthly average temperature. As in the previous section, the effect of meter reading discrepancies was taken into account, and the monthly average temperature for each month was calculated by taking the average temperature of the previous month x 0.5 + average temperature of the current month x 0.5.[7] Dummy variables were set for the COVID-19 pandemic factor, with the assumption that there was an effect from April 2020 to March 2022, which was when the second round of priority measures to prevent the spread of the disease ended. Time trend factors include changes in trends such as fuel substitution between city gas and electricity or kerosene (or other forms of fuel), improvements in the energy efficiency of appliances, downsizing of households, and lifestyle changes. Other factors refer to factors not included in the abovementioned, including the contribution of changes in multiple factors at the same time.

Figure 3 shows the month-on-month difference in residential city gas sales volume from January to November 2024 and the contribution of each factor. The temperature factor contributed to an increase in sales volume from January to February and from September to November 2024, as temperatures were falling month to month; conversely, the temperature factor contributed to a decrease in sales volume from March to August. This confirms that temperature has a significant impact on residential city gas sales volume, with the exception of February and September when the month-on-month temperature difference was small. Other factors were the next most important, coming after temperature, so it can be said that residential city gas sales volume is largely determined by the conditions of each month.

Figure 4 shows the contribution of each factor to the month-on-month difference in residential city gas sales volume from January to November 2024, excluding temperature and other factors. In February, when there are fewer days in the month, residential city gas sales volume decreased the most by 1.8 PJ, due to the number of days. The number of assessed bills per household and the number of households increase or decrease from month to month. Residential city gas sales volume increased by 0.12 PJ in March, 0.12 PJ in April, and 0.10 PJ in May due to changes in the number of households; in relation to the number of bills assessed per household, sales volume increased by 0.08 PJ in April 2024 and decreased by 0.09 PJ in the following month of May. In other words, factors related to the number of customers in the residential sector show a relatively large increase or decrease during the period when many people move houses or change their lifestyles in preparation for the new fiscal year. In addition, the time trend factor contributes to a monthly decrease in residential city gas sales volume ranging from 0.01 PJ to 0.04 PJ. As explained above, this is likely to reflect changes in trends such as fuel substitution, improvements in the energy efficiency of appliances, and downsizing of households.

[4] The number of bills assessed refers to the number of meters for which gas bills are issued.

[5] Due to the nature of energy as a daily necessity, it is extremely difficult for households to curb their usage even when prices rise. Support for reducing gas bills was provided through the "Emergency Assistance to Survive the Severe Heat" from August to October 2024 and the "Electricity and Gas Fee Burden Reduction Support Program" from January to March 2025. Given the inelastic nature of city gas prices, we can say that these measures were effective from the viewpoint of reducing the burden on people's lives. On the other hand, since support to reduce gas bills will no longer be provided from April 2025, the burden of gas bills on households is set to increase amid the momentum of rising prices.

[6] Calculated by taking number of days in the previous month × 0.5 + number of days in the current month × 0.5

[7] Similarly, for the number of days, the effect of meter reading discrepancies was taken into account, and the average number of days in the previous and current months was used as an assumption in the analysis of the degree of contribution.

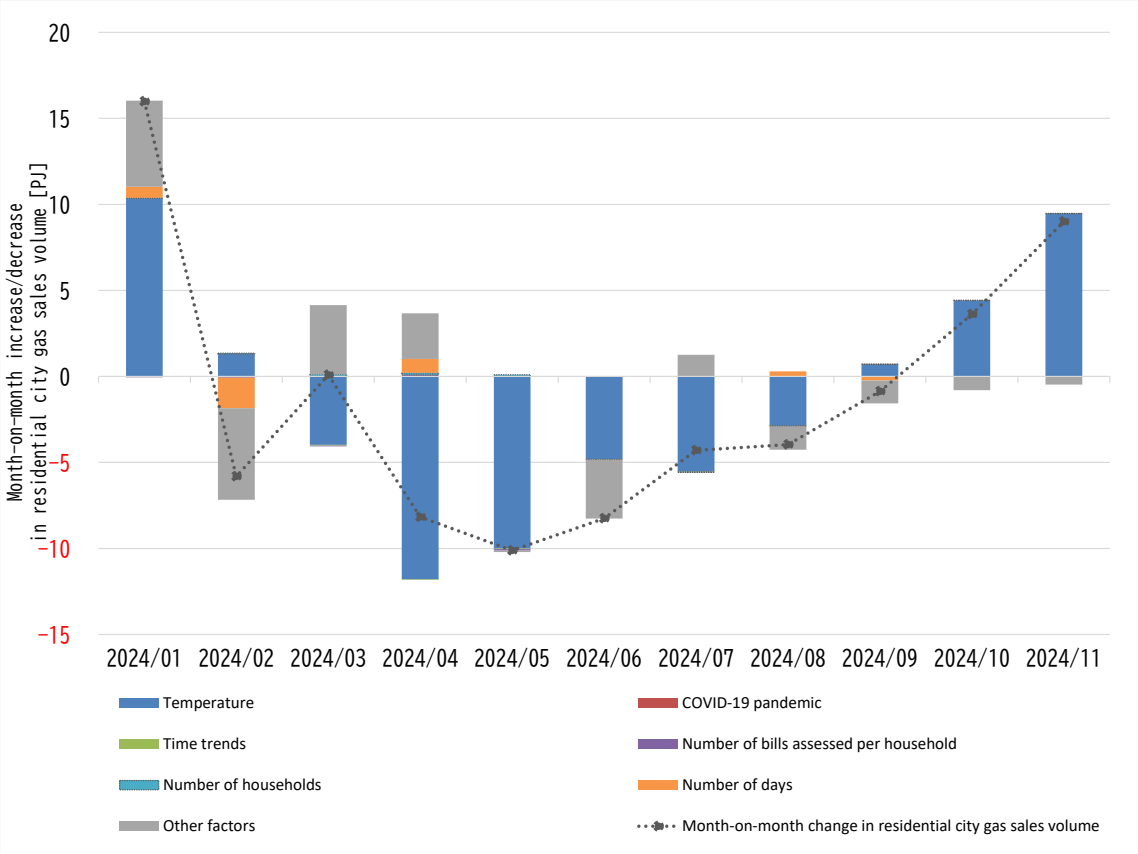

Figure 3 Month-on-month difference in residential city gas sales volume in 2024, and contribution of each factor
(Source: Estimated based on Current Survey of Production Concerning Gas Industry, Japan Meteorological Agency, and Labour Force Survey)

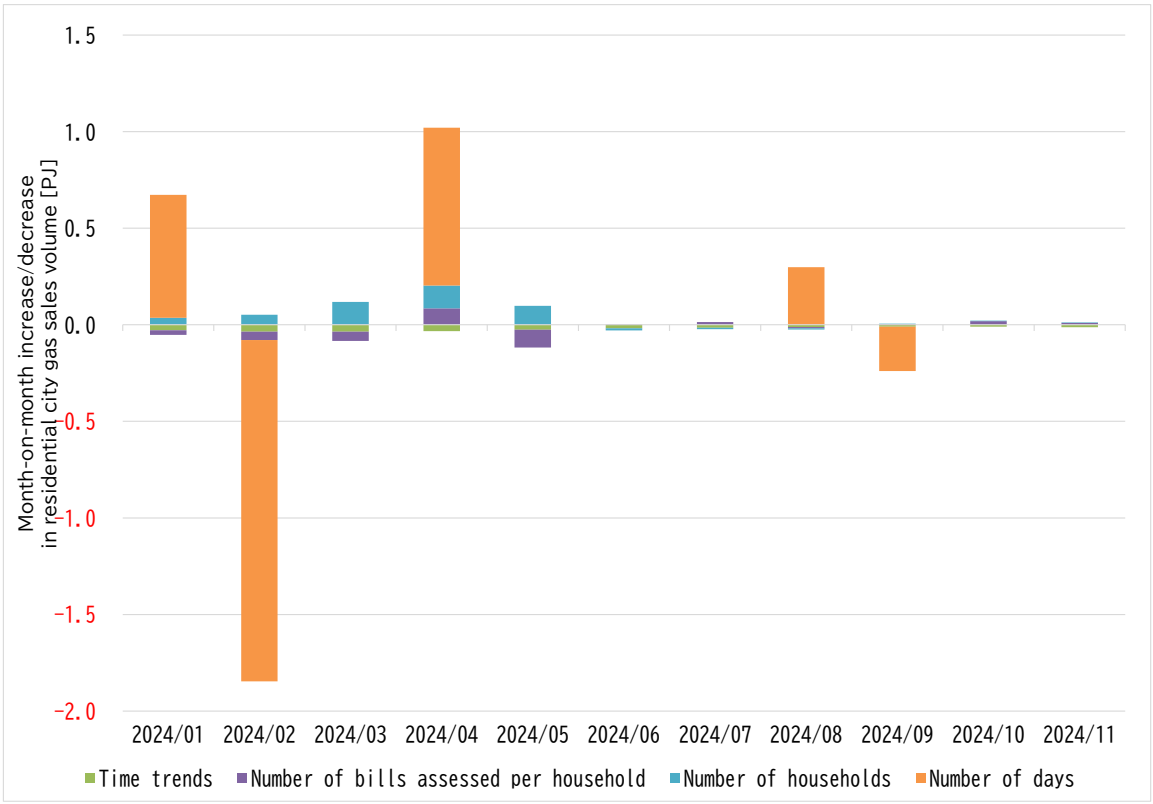

Figure 4 Month-on-month difference in residential city gas sales volume in 2024, and contribution of each factor (excluding temperature and other factors)
(Source: Estimated based on Current Survey of Production Concerning Gas Industry, Japan Meteorological Agency, and Labour Force Survey)

So far, this paper has looked at the fluctuations by month in 2024. Next, to examine the factors contributing to fluctuations in residential city gas sales by year, **Figure 5** shows the year-on-year differences and contributions from 2016.

The temperature factor contributed significantly from 2016 to 2017 and from 2017 to 2018; from 2018 to 2019, although the temperature factor contributed to reducing residential city gas sales volume, the increase in the number of households contributed significantly at 4.8 PJ which, along with the upward contribution of other factors, resulted in an overall year-on-year increase in residential city gas sales volume. As the percentage of people staying home increased due to the spread of the COVID-19 pandemic, the COVID-19 pandemic factor led to an increase of 20 PJ from 2019 to 2020, contributing to an increase in residential city gas sales volume in 2020. From 2020 to 2023, the opportunities to go out increased every year as the COVID-19 pandemic subsided, contributing to a decrease in residential city gas sales volume of up to 15.5PJ (from 2021 to 2022). From 2023 to 2024, temperature contributed to a fall in sales volume, but an increase in the number of households, the number of days due to a leap year, and other factors contributed to an overall year-on-year increase.

To further examine the long-term impact, **Figure 6** shows the cumulative contribution from 2016 to 2024, in order from the factors with the largest cumulative contribution over the eight-year period: time trends, number of households, temperature, other, number of bills assessed per household, and COVID-19. The time trend factor maintained a decrease of 3.1 PJ to 3.3 PJ each year, resulting in a cumulative decrease in sales volume of 26.0 PJ. The number of households was on a rising trend due to the shift toward nuclear families, contributing to a 23.8 PJ increase in sales volume. The number of bills assessed per household was also on a slight upward trend except from 2023 to 2024, and contributed 3.8 PJ to the increase in sales volume. Therefore, when looking at long-term changes in residential city gas sales volume, the range of fluctuation due to temperature is relatively small, as increases and decreases are offset. For this reason, it is also important to note the contribution of fuel substitution, improvements in the energy efficiency of appliances, and downsizing of households to a decrease in sales volume, and the contribution of the number of bills assessed, for example, due to an increase in households or expansion in city gas supply areas, to an increase in sales volume.

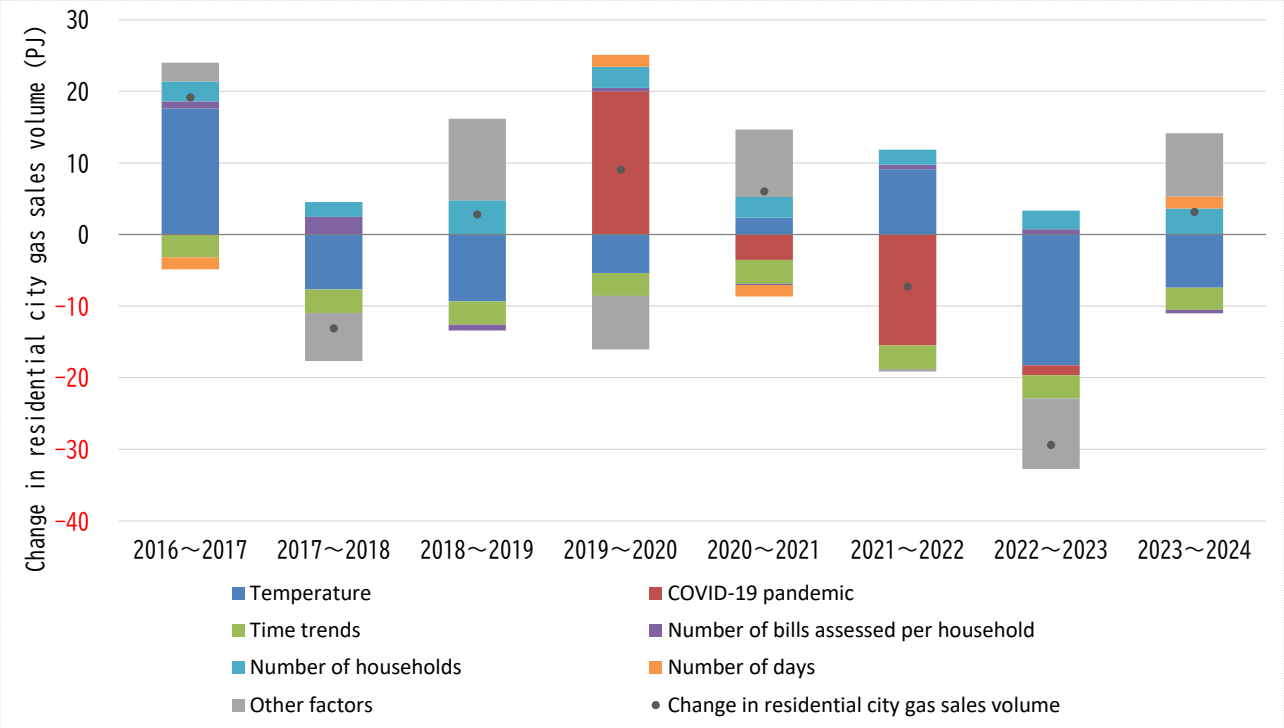

Figure 5 Year-on-year difference in residential city gas sales volume, and contribution of each factor
(Source: Estimated based on Current Survey of Production Concerning Gas Industry, Japan Meteorological Agency, and Labour Force Survey)

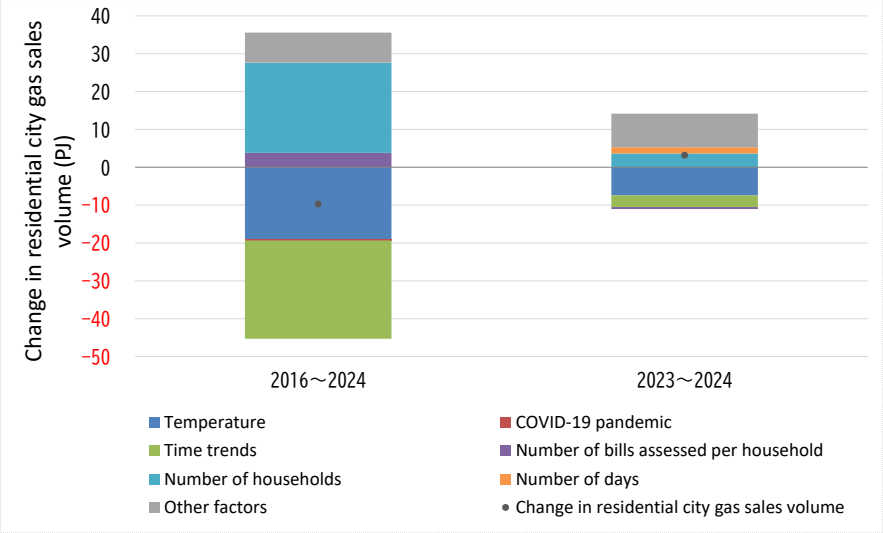

Figure 6 Changes in residential city gas sales volume, and contribution of each factor
(Source: Estimated based on Current Survey of Production Concerning Gas Industry, Japan Meteorological Agency, and Labour Force Survey)

5. Conclusion

This paper examined the factors behind the fluctuations in residential city gas sales volume in recent years.

Since city gas is used for water heating and air conditioning, lower temperatures have the effect of increasing residential city gas sales volume. Regarding this effect of temperature, it is necessary to consider not only the average temperature of the current month, but also the average temperature of the previous month, while taking into account the effect of meter reading discrepancies from meter readings taken through house visits.

Seasonal fluctuations in residential city gas sales volume can be attributed to changes in the number of households, the number of bills assessed, and the number of days. Changes in the number of households and the number of bills assessed are relatively large, particularly at the end and the beginning of a fiscal year. Moreover, the number of households is increasing year by year, and although there are also periods when the number of bills assessed per household decreases by month, it is on a rising trend on an annual basis, and is therefore making a small but steady contribution to the increase in residential city gas sales volume.

In the long term, trends such as fuel conversion, improvements in the energy efficiency of appliances, and downsizing of households, as well as changes in the number of households, will contribute to increases or decreases in residential city gas sales volume. Residential city gas sales volume is on a declining trend due to the aforementioned factors. While the number of households has been increasing to date, according to the Household Projections for Japan published by the National Institute of Population and Social Security Research, the number of private households will begin to decline from 2031. The outlook for the extreme long term suggests the possibility of a further decline in residential city gas sales volume, particularly due to the growing shift toward electrification of water heating, space heating, and cooking appliances with a view to enhancing convenience and contributing to decarbonization. Therefore, there is a need to continue monitoring the trends closely.

Contact: report@tky.ieej.or.jp