

Population decline and electricity demand in Japan: myth and facts

Economic growth, energy conservation and electrification affect electricity demand more than population

YANAGISAWA Akira

Senior Economist and Manager

Energy Demand, Supply and Forecast Analysis Group, The Energy Data and Modelling Center

Summary

We often hear a view that “Japanese electricity consumption is decreasing due to the population decline.” Compared to the frequency with which this is repeated, quantitative analysis of the relationship between population decline and electricity demand has been quite rare. This paper is an attempt at a concise analysis of this relationship based on historical data.

Increases in population and electricity consumption in Japan seem to have occurred simultaneously. Furthermore, it can be seen that electricity consumption moved into a declining curve from FY2008 alongside population, which recorded a historical high in 2008 and then began to decrease. However, concluding that “population decline results in decreases in electricity consumption” based only on this impression would be somewhat premature.

Populations in the areas of seven general electric utilities other than Tokyo, Chubu and Kansai Electric Power Companies – namely Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies – have already declined over more than 15 years since 1998. Electricity consumption, however, had increased almost consistently before the global financial crisis. Whilst the populations in the seven electric utilities’ areas declined by 3% from the peak of 1997 to 2010 before the Great East Japan Earthquake, electricity consumption increased by 22% over the same period. Viewed until 2013, the population has declined by 4% whereas electricity consumption has increased by 16%, despite progress in saving electricity after the Earthquake.

The decomposition analysis results of changes in electricity consumption in Japan clearly show that contribution by demographic is not so large and major factors are energy conservation, electrification and economic growth. Acceleration of the population decline is expected in the future, but still, for example, the rate of decline in the next decade (2013-2023) is expected to be about 0.4% per annum. The connotations of the term “population decline” may give us the impression that a serious impact on various fields in the society is occurring. However, in reality, contribution by the population decline to decreases in electricity consumption is limited.

Meanwhile, with respect to economy, for instance, growth of 0.8% p.a. in real GDP per capita is expected even in the “Baseline Case,” a modest case from the Cabinet Office’s “Medium- and Long-Term Economic and Fiscal Estimates.” Final energy consumption decreases by 1.2% p.a. in the next decade under these population and economic assumptions combined with energy conservation and electrification progress equivalent to the trend in the period after FY2000. Electricity consumption, however, does increase by 0.6% p.a.

Energy and electricity have the nature of being goods to support the supply of other goods and services as well as being consumer goods themselves. Decreases in the labour force must be compensated by other production factors, etc. in order to keep a certain production level when a declining productive population causes a labour shortage problem. Such factors are greater technological advances, more capital and more energy. In the future, population decline may induce increases in electricity demand, not decreases.

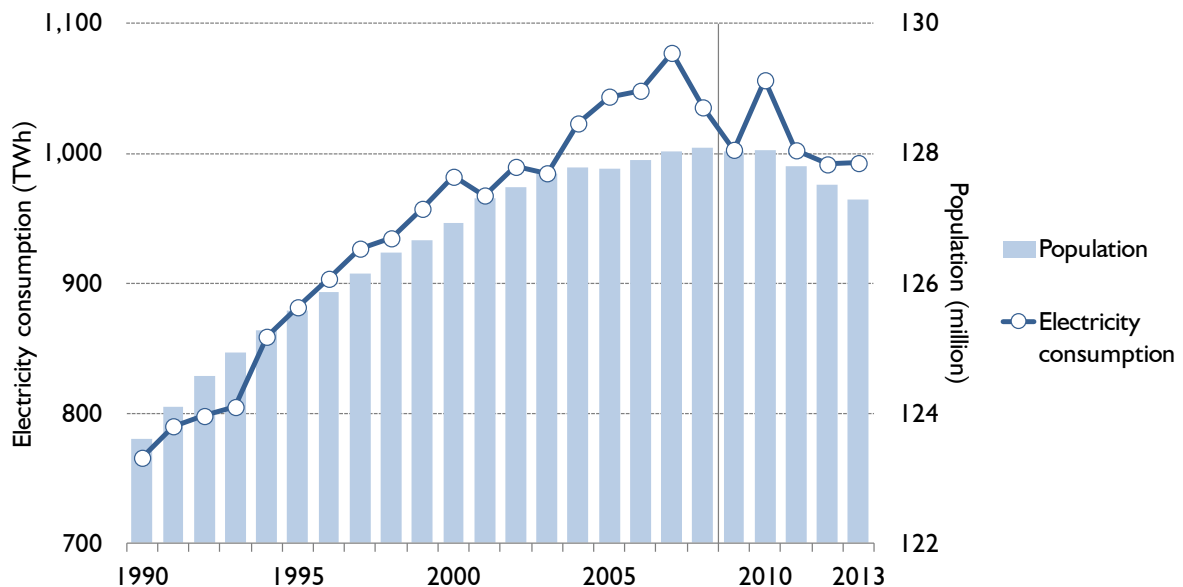
No more increase? Japan's electricity consumption

Demographics are treated as an important factor along with economic growth¹ and energy prices when we consider energy or electricity demand. We also often hear a view that “Japanese electricity consumption will decrease since the population has turned to a decline.” Compared to the frequency with which this is repeated, quantitative analysis of the relationship between population decline and electricity demand has been quite rare. This paper is an attempt at a concise analysis of this relationship based on historical data.

Population is a factor that affects demand for various goods and services. It is quite difficult to expect an upward trend to evolve for matters considered to be closely related to the number of people – e.g. sales of toothbrushes, the consumption volume of Christmas cakes and total visitors to hairdressers – in situations where population declines. However, can we truly take a firm stance based on a view that fatalistically presumes that demand for goods and services will decrease and the economy will fail to grow when population declines? Or is this just extreme simplification?

Increases in population and electricity consumption in Japan seem to have occurred simultaneously. Furthermore, it can be seen that electricity consumption moved into a declining curve from FY2008 alongside population, which recorded a historical high in 2008 and then began to decrease.

Figure 1 | Electricity consumption and population [Japan]



Note: Electricity consumption consists of electric utilities and autoproducers of electricity for each fiscal year. Population is as of 1st October.

Source: Ministry of Economy, Trade and Industry “Electricity Survey,” Ministry of Internal Affairs and Communications “Population Estimates”

¹ Economic growth is also affected by demographic.

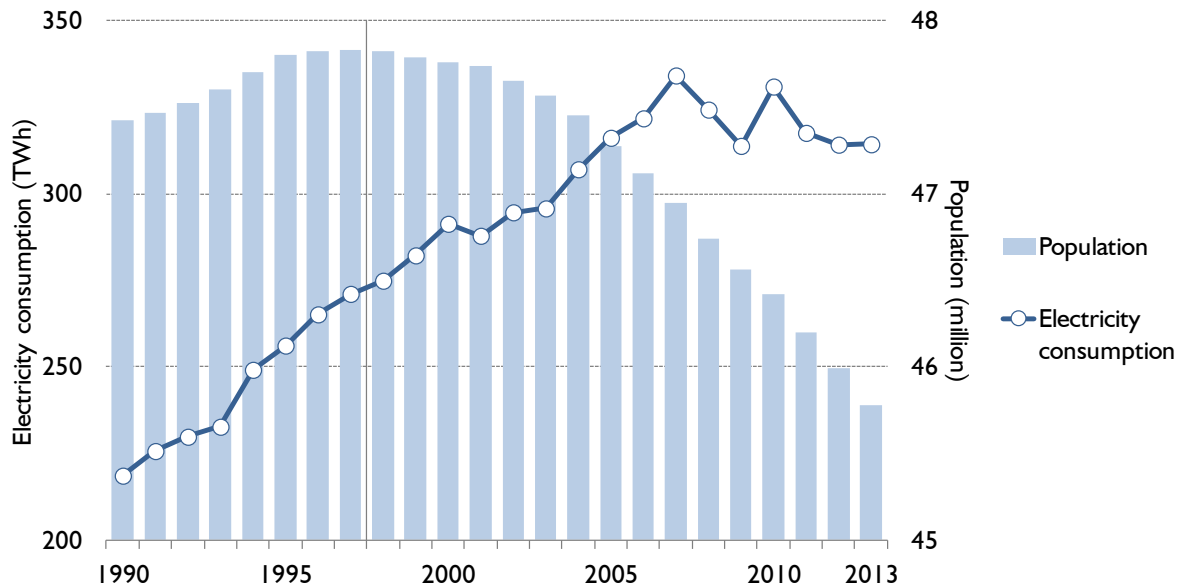
However, concluding that “population decline results in decreases in electricity consumption” based only on this impression would be somewhat premature. The global financial crisis triggered by the Lehman Shock had a heavy impact on the significant drop in electricity consumption in FY2008 and FY2009. Even electricity consumption in the entire world decreased in 2009 for the first time since World War II. The sharp reduction in FY2011 was caused by the powerful electricity-saving movement due to the electricity shortage after the Great East Japan Earthquake and a backlash from the previous year’s record hot summer. Furthermore, no small danger accompanies tying population decline to decreases in electricity consumption based only on the situation of just a few years, e.g., in FY2012 when production activity was low before the full-scale implementation of “Abenomics,” or in FY2014 that saw an economic downturn after the value added tax hike and the coolest summer in five years.

Electricity consumption increases despite population decline – rural areas anticipate the future society of population decline

We, however, can observe the relationship between population decline and electricity consumption over a longer period by slightly changing the viewpoint.

Population in the combined areas of Tokyo, Chubu and Kansai Electric Power Companies increased until 2010. Conversely, populations in the areas of the other seven general electric utilities – namely Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies – have already declined over more than 15 years since 1998 (Figure 2).

Figure 2 | Electricity consumption and population [areas of Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies]



Note: Electricity consumption consists of the sales volumes of Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies for each fiscal year. Population consists of Hokkaido, the Tohoku region, Niigata, Toyama, Ishikawa, Fukui, the Chugoku region, the Shikoku region, the Kyushu region and Okinawa as of 1st October.
Source: Ministry of Economy, Trade and Industry “Electricity Survey,” Ministry of Internal Affairs and Communications “Population Estimates”

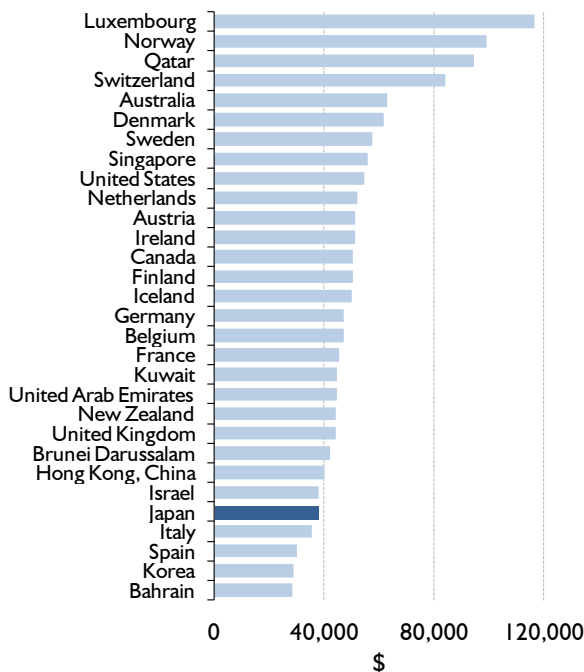
Electricity consumption, however, increased almost consistently before the global financial crisis. Whilst the populations in the seven electric utilities' areas declined by 3% from the peak of 1997 to 2010 before the Great East Japan Earthquake, electricity consumption did increase by 22% over the same period. Viewed until 2013, the population has declined by 4% whereas electricity consumption has increased by 16%, despite progress in saving electricity after the Earthquake.

The relationship over the medium term eloquently informs us that the impact of demographics on electricity consumption is weaker than generally supposed. Nonetheless, the naive theory that “electricity consumption decreases due to population decline” tends to be believed. The reason may be that people envisage the structure as shown below and electricity consumption per capita does not increase more in a rich country like Japan:

$$\text{Electricity consumption} = \text{Population} \times \text{Electricity consumption per capita.} \tag{1}$$

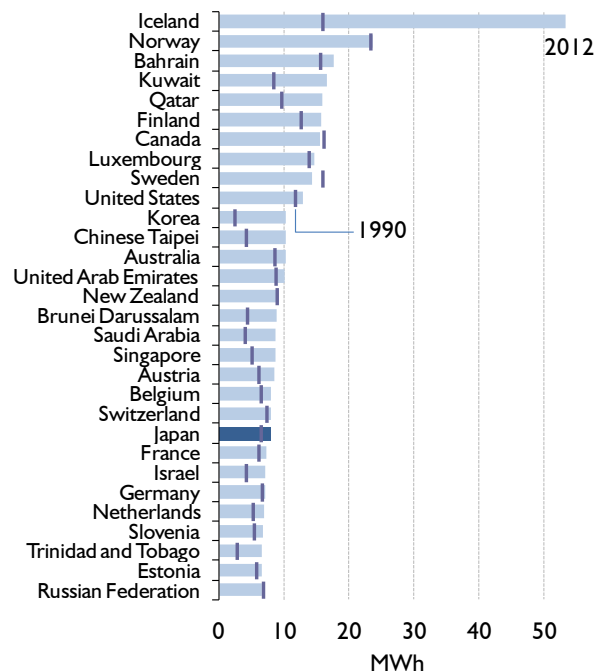
Japan, however, is unfortunately not one of the richest countries in the world anymore (Figure 3). In addition, electricity consumption per capita showed an increasing trend for household as well as industry and commercial uses until the powerful electricity-saving measures after the Earthquake were implemented. If we take an overview of the world, not a few countries are richer and consume more electricity per capita than Japan². Electricity consumption per capita increases further even in such high-consuming countries (Figure 4). Inferring from these facts, it may be difficult to say that Japanese electricity consumption per capita has already reached the upper limit or a saturation level with no room for any more increase.

Figure 3 | GDP per capita in top 30 countries (2014)



Source: International Monetary Fund “World Economic Outlook, October 2014”

Figure 4 | Electricity consumption per capita in top 30 countries (1990 and 2012)



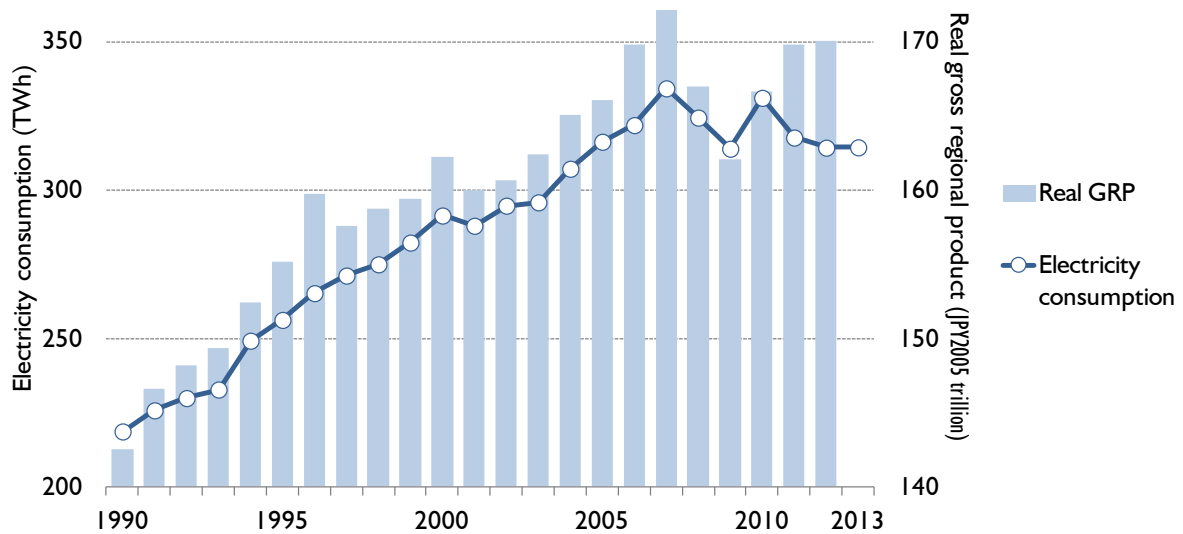
Source: International Energy Agency “Energy Balances of OECD/Non-OECD Countries, 2014”

² Industrial structure and climate conditions also affect differences in electricity consumption. There is also an aspect that the high electricity rate and energy efficiency of Japan reduce electricity consumption. Conversely, low electricity prices due to political subsidies or abundant cheap power sources such as hydro induce high electricity consumption in some countries.

Economy and energy consumption structure affect electricity demand more strongly than population

Again, electricity consumption has increased despite the population decline in the seven companies' areas. Then, what kinds of factors can we find to specifically define electricity demand? For example, comparing Figures 2 and 5, although this comes as no surprise, it would be natural to think that electricity demand is significantly affected by economy.

Figure 5 | Electricity consumption and real gross regional product [areas of Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies]



Note: Electricity consumption is the sales volume of the seven electric power companies for each fiscal year. Real gross regional product (GRP) consists of Hokkaido, the Tohoku region, Niigata, Toyama, Ishikawa, Fukui, the Chugoku region, the Shikoku region, the Kyushu region and Okinawa for each fiscal year. GRP before FY2000 is compiled from the series in 1995 prices. GRP in FY2013 has not been released yet.

Source: Ministry of Economy, Trade and Industry "Electricity Survey," Cabinet Office "Prefectural Accounts"

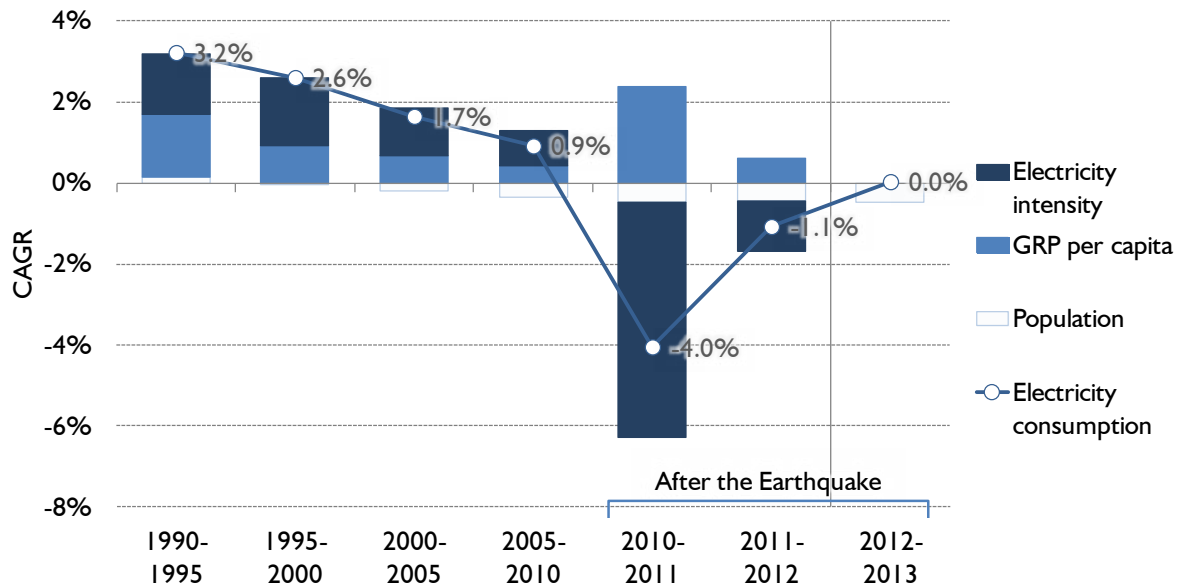
Equation (1) for electricity consumption can be modified as below to include the economic factor as well as the demographic factor:

$$\begin{aligned}
 \text{Electricity consumption} &= \text{Population} \times \frac{\text{GDP}}{\text{Population}} \times \frac{\text{Electricity consumption}}{\text{GDP}} \\
 &= \text{Population} \times \text{GDP per capita} \times \text{Electricity intensity.}
 \end{aligned}
 \tag{2}$$

The decomposition analysis³ results of changes in electricity consumption in the seven electric power companies' areas based on equation (2) clearly show that contribution by the demographic to electricity consumption is not so large compared to the other factors (Figure 6).

³ Electricity consumption is the sales volume of the seven electric power companies. Gross regional product, not gross domestic product, is used since the analysis is conducted for the region rather than the country.

Figure 6 | Decomposition analysis of changes in electricity consumption [areas of Hokkaido, Tohoku, Hokuriku, Chugoku, Shikoku, Kyushu and Okinawa Electric Power Companies]



Note: Electricity consumption is the sales volume of the seven electric power companies for each fiscal year. Real gross regional product (GRP) consists of Hokkaido, the Tohoku region, Niigata, Toyama, Ishikawa, Fukui, the Chugoku region, the Shikoku region, the Kyushu region and Okinawa for each fiscal year. GRP before FY2000 is compiled from the series in 1995 prices. Electricity intensity is electricity consumption per real GRP. Complete decomposition analysis in FY2013 is not possible since GRP has not been released yet.

Source: Compiled from Ministry of Economy, Trade and Industry “Electricity Survey,” Cabinet Office “Prefectural Accounts” and Ministry of Internal Affairs and Communications “Population Estimates”

Electricity increases whilst total energy decreases

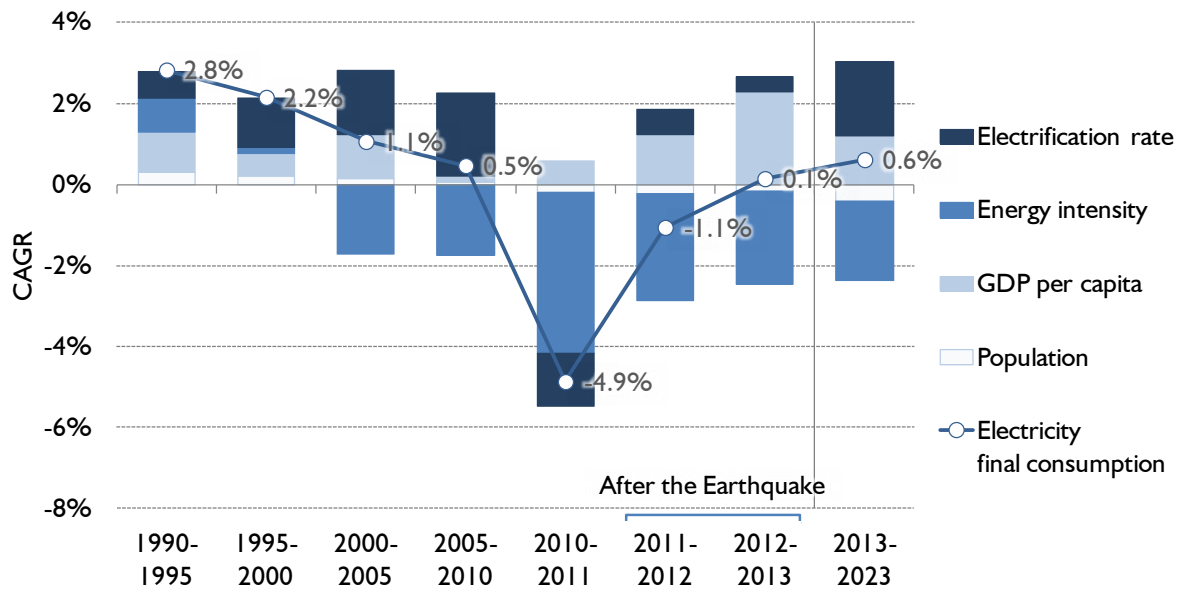
Furthermore, electricity consumption can be expressed as follows if handled by explicitly switching between electricity and other energy sources:

$$\begin{aligned}
 \text{Electricity consumption} &= \text{Population} \times \frac{\text{GDP}}{\text{Population}} \times \frac{\text{Total energy consumption}}{\text{GDP}} \times \frac{\text{Electricity consumption}}{\text{Total energy consumption}} \\
 &= \text{Population} \times \text{GDP per capita} \times \text{Energy intensity} \times \text{Electrification rate}.
 \end{aligned}
 \tag{3}$$

Figure 7 shows the decomposition analysis⁴ results of changes in the national electricity consumption based on equation (3).

⁴ Electricity consumption consists of the final consumption of all electric utilities and autoproducers. Energy consumption is the final energy consumption base.

Figure 7 | Decomposition analysis of changes in electricity consumption [Japan]



Note: Energy intensity is the final energy consumption per real GDP and electrification rate is the final energy consumption base. For FY2013-2023, population refers to the National Institute of Population and Social Security Research “Population Projections for Japan” (January 2012). GDP refers to the “Baseline Case” of the Cabinet Office’s “Medium- and Long-Term Economic and Fiscal Estimates” (February 2015). Changes in energy intensity and electrification rate refer to the trend in the period from FY2000 to FY2013 except for FY2011.

Source: Compiled from Institute of Energy Economics, Japan “EDMC Handbook of Energy & Economic Statistics”

Contribution by the population decline to reducing electricity consumption is limited also at the country level. As a trend since 2000, whilst energy conservation (improvement in energy intensity) works to restrain electricity consumption, progress in electrification and economic growth push it up. Energy conservation and electrification curbing advanced unusually in FY2011 just after the Earthquake. After the year, however, energy conservation slowed and electrification turned to progress again. These backlashes combined with the economic recovery broke the decreasing trend of electricity consumption in the two years of FY2011 and FY2012.

Acceleration of the population decline is expected in the future, but still, for example, the rate of decline in the next decade (2013-2023) is expected to be about 0.4% per annum. The connotations of the term “population decline” may give us the impression that a serious impact on various fields in the society is occurring. However, in reality, contribution by the population decline to decreases in electricity consumption is limited.

Meanwhile, with respect to economy, for instance, growth of 0.8% p.a. in real GDP per capita is expected even in the “Baseline Case,” a modest case from the Cabinet Office’s “Medium- and Long-Term Economic and Fiscal Estimates.” Final energy consumption decreases by 1.2% p.a. in the next decade under these population and economic assumptions combined with energy conservation of 2.0% p.a. and progress of electrification of 1.8% p.a., which are equivalent to the trend in the period from FY2000 to FY2013⁵. Electricity consumption, however, does increase by 0.6% p.a. whilst total energy consumption decreases.

As another estimation, if we assume more rapid energy conservation (2.5% p.a.) and slower progress in electrification (0.5% p.a.), which has been seen in the last two years, electricity consumption decreases by 1.2%

⁵ As adding new energy and electricity saving every year at the level that was implemented just after the Earthquake is not considered to be easy, FY2011 is excluded from the trend calculation.

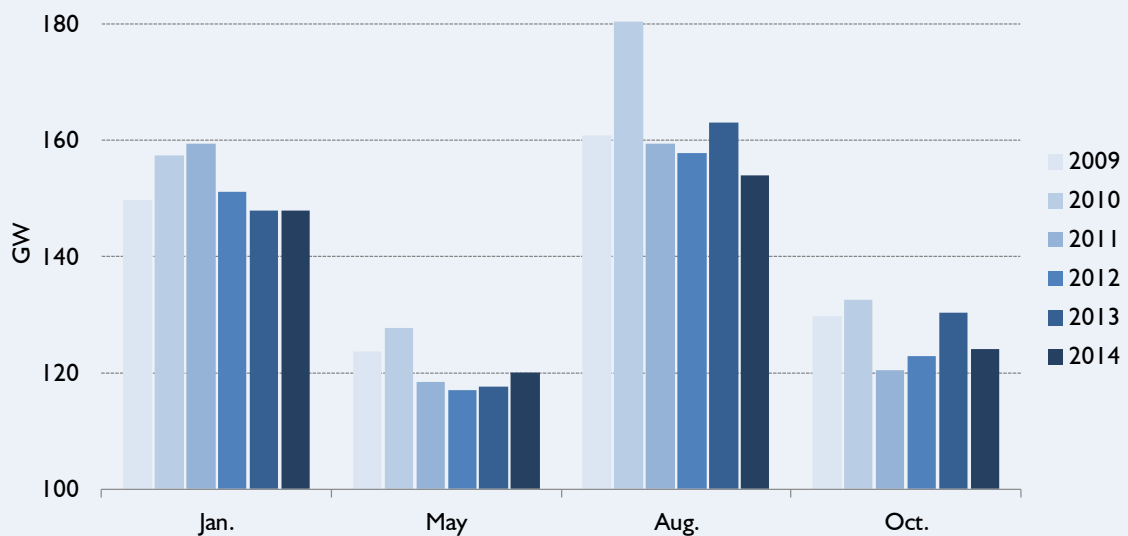
p.a. It should be noted, however, that three years is the longest record for continuously achieving the assumed 2.5% p.a. or more of energy conservation, even if we refer to the data for the past half-century. For slow progress in electrification with less than 0.5% p.a. for the second consecutive year, we can find records only in the late 1960s of the high economic growth period of Japan⁶.

Box I | Electricity consumption in 2014

It is difficult to capture the trend of electricity consumption from its short-term movements. For example, electricity consumption⁷ decreased by 1.5% in 2014 from the previous year. To this, some have tried to find an argument for the persistence of saving electricity after the Earthquake. We, however, are required to carefully evaluate the situation, not confusing short-term movements and the medium- and long-term trend.

In 2014, the economic slump was remarkable after the VAT increase in April, especially after the summer. Furthermore, temperatures during the cooling period were low. There is a high possibility that the decreases in electricity consumption were caused by a fall in energy service demand after the middle of the year, rather than electricity saving. For instance, if we look at the peak demand of electricity, the consumption in August and October recorded -5% decreases year-on-year when the economy and temperatures showed anomalies (Figure 8). In contrast, in January and May, consumption was greater than in the same month of the previous year.

Figure 8 | Combined peak demand of electricity (2014)



Note: The nine areas of the Electric Power System Council of Japan
 Source: Electric Power System Council of Japan

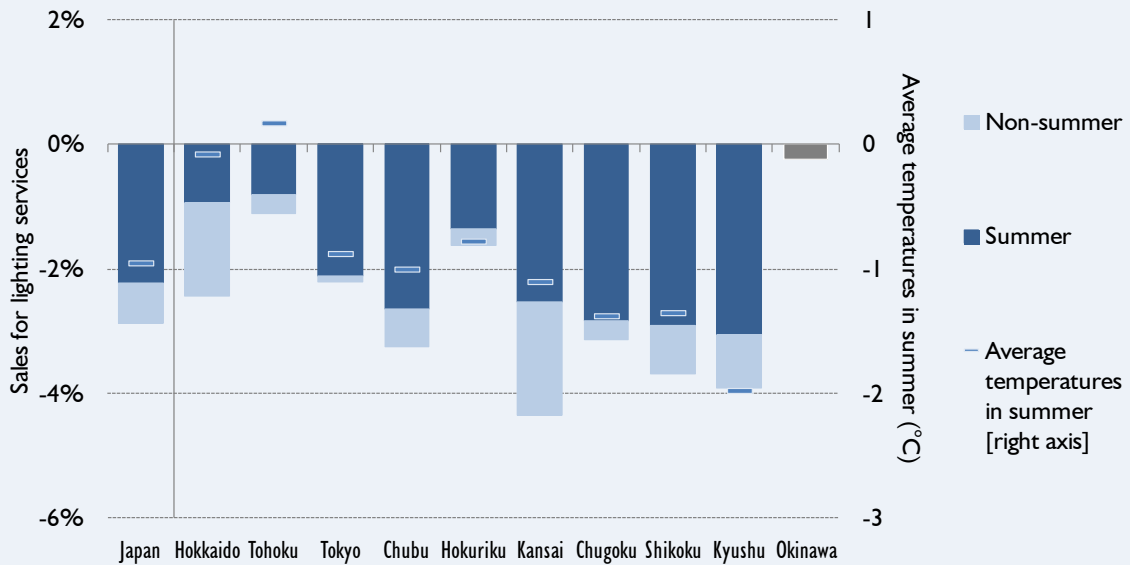
The influence of the summer, the chilliest in five years, appeared more remarkably in residential electricity consumption, which highly depends on temperatures. Sales volume for lighting services, of the general electric utilities, mainly for households, fell by 8.1 TWh, or 2.9%, in 2014. Decreases of 6.3 TWh are

⁶ At that time, the situation was that electricity lost its share in the rapid growth of total energy consumption. Electricity consumption did not stagnate but grew by 12-15% p.a.

⁷ All electric utilities and autoproducers.

concentrated in four months of the summer⁸, accounting for around 80% of the annual decreases (Figure 9). Cooler areas tend to have recorded significant reductions of electricity consumption.

Figure 9 | Changes in sales for lighting services and contribution by period (2014)



Note: General electric utilities. Summer consists of June, July, August and September. Temperatures refer to those in cities where the head office of each power company is located and nationwide is their weighted average with population. Contribution by period in Okinawa is not calculated since its climate is significantly different from the others. Source: Compiled from Federation of Electric Power Companies of Japan “Electricity Statistics Information” and Japan Meteorological Agency data

If we foresee a society with a future population decline...

Population decline is hardly recognised to constrain electricity consumption as much as is generally supposed. The recent decreases in electricity consumption have been caused by the dull economic activity and electricity-saving efforts – further energy conservation and slowing progress in electrification – rather than the population decline. Looking at the medium term, if electricity consumption turns to a declining trend, what pulls the trigger may be stagnations of economy and/or of electrification progress, not population decline.

In this paper, we tried conducting an analysis from the perspective of whether population decline may result in decreases in electricity consumption. There may be a need, however, to verify an opposite view in the society of the future featuring a population decline. Energy and electricity have the nature of being goods to support the supply of other goods and services as well as being consumer goods themselves. Decreases in the labour force must be compensated by other production factors, etc. in order to keep a certain production level when a declining productive population causes a labour shortage problem. Such factors are greater technological advances, more capital and more energy. In the future, population decline may induce increases in electricity demand, not decreases.

Contact: report@tky.iej.or.jp

⁸ June to September