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An Estimate on the Impact of a "City Lockdown" on Japan's Energy Demand

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Introduction

The novel coronavirus (COVID-19) infection has become a pandemic and its impact is expanding in scale and severity. To prevent the contagion from spreading further, the governments of the world's major countries have issued emergency declarations and similar statements, taking powerful measures such as blocking or locking down cities, and imposing restrictions on the movement of people, economic activity, and the daily lives of citizens in highly-populated cities. Since the end of March, there has been a growing possibility of a state of emergency or a kind of "city lockdown" for Tokyo and other cities in Japan.

Measures such as greatly restricting the movement of people, economic activity, and the lives of citizens in cities with large populations and high levels of economic activity will inevitably cause a significant drop in energy demand. Actual lockdown measures already imposed in other countries and cities vary considerably; the magnitude of the fall in energy demand will also depend on the measures and level of restrictions. The scale of the fall in demand, and for which type of energy, will have a major impact on Japan's energy sourcing and securing of supplies, as well as on the energy industry and the international energy market.

In view of these issues, this report estimates[3] the decrease in energy demand if a kind of "city lockdown" is enforced. Using cities with a population of 2.5 to 10 million, we set up various hypotheses for the decrease in activities in different sectors based on the energy data for each prefecture (national data was also used in some cases). The following sections describe the framework of the calculation for each area and sector and assess the decrease in energy demand per day.

Framework of the calculation

This report focuses on activities within a city and calculates the decrease in energy demand for the manufacturing and construction industries, households, businesses, and automobiles. Areas such as agriculture, forestry, and fishery and inter-city transport are not included. Therefore, the calculated decrease in energy demand does not represent the entire decrease in energy demand that a kind of "lockdown" would actually cause. As the scale of "lockdown" is not yet clear, the impact on energy demand was estimated for each industry based on the conditions of "lockdowns" already imposed in Europe and the United States, as follows.

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[3] There are 12 "major cities" in Japan, including the Tokyo Metropolis (population of 13.7 million, including 9.3 million in the special wards), Yokohama City (3.7 million), and Osaka City (2.7 million) (as of 2017). These cities together account for 27% of Japan's total population. Prefectures with the largest populations include the Tokyo Metropolis, Kanagawa (9.2 million), Osaka (8.8 million), Aichi (7.5 million), Saitama (7.3 million), and Chiba (6.2 million).

The impacts on the manufacturing and construction industries were estimated at the sector level. As the supply of daily necessities is critical, we assumed that the final demand for food, medical supplies, and daily consumables (sanitary paper products, detergents, cosmetic products, etc.) will be met. We also assumed that the production of supplies necessary to maintain the minimum necessary services such as energy and water supply, telecommunications and broadcasting, cargo and passenger transport, and retail will continue. The rate of decrease in production (i.e. the rate of suspension of operation) of goods and services other than the bare minimum described above was estimated using the input-output table for the whole of Japan.

Table 1 Assumptions for the impact on energy demand for the manufacturing and construction industries (major sectors)

Sector	Construction	Foods	Paper	Chemicals	Ceramics	Metals	Machinery
Operation suspension rate	92%	20%	42%	26%	67%	54%	68%

The impact on residential energy demand was estimated by purpose of use. Energy demand for the kitchen, and power and lighting are expected to increase as more people stay home during the daytime due to requests to stay at home and telework. Air conditioning was assumed to have no impact on demand as it is hardly used in April, which is the “lockdown” period in this report, though this depends on the region.

Table 2 Assumptions for impact on energy demand for households

Purpose	Impact	Assumption
Air conditioning	0%	No impact as air conditioning will hardly be used during a “lockdown” in April, though this depends on the region.
Hot water supply	0%	No increase or decrease expected as it is used mostly at night.
Kitchen work	Up approx. 10%	For lunch: Increases in line with the number of people staying home during the daytime (from 0.7 → 1.8 persons on average). For dinner: Increases in line with the decrease in eating out (which is usually around once every 10 days).
Power / lighting	Up approx. 15%	Increases for day-time lighting and use of TV, PCs, and gaming devices as more people stay at home during the daytime.

The impact on demand for business-use energy was estimated by sector and purpose of use. Many offices and shops will close as the bulk of office workers switch to teleworking and more people refrain from going outside unless essential, but supermarkets (food), pharmacies, and hospitals will continue to operate. The decrease in energy demand for hot water supply and kitchen work is estimated to be equivalent to the suspension rate in relevant sectors. However, the decline for power and lighting was set considering that they will continue to be used even during a business suspension.

Table 3 Assumptions for impact on energy demand for business-use (by sector)

Sector	Suspension rate	Assumption
Offices	70%	Bulk of employees telework. Commuting to offices needed for some government offices and companies.
Supermarkets	20%	Department stores close. General merchandise stores close floors not selling food.
Other wholesalers & retailers	50%	Wholesalers and retailers other than food and medical supplies close.
Food services	80%	Some remain open for take-out service.
Schools	100%	All schools close.
Hotels	50%	Many continue to operate but occupancy rate falls significantly.
Hospitals	0%	Operate as usual.
Entertainment	100%	All stores and facilities suspend operations.
Other	70%	Welfare facilities continue to operate.

Table 4 Assumptions for impact on energy demand for business-use (by purpose of use)

Purpose	Impact	Assumption
Air conditioning	0%	No impact as air conditioning would hardly be used during a lockdown in April, though this depends on the region.
Hot water supply	Down approx. 60%	Based on the collective suspension rate of different sectors.
Kitchen work	Down approx. 60%	Based on the collective suspension rate of different sectors.
Power / lighting	Down approx. 50%	Based on the collective suspension rate of different sectors. Assumed that 20% of demand remains for purposes which are uninterrupted by business suspension (ventilation, refrigerators, servers, etc.).

The impact on energy demand for automobiles was estimated by type of vehicle. Most private vehicles and taxis will stop being used as people refrain from going out except for essential purposes, but buses and freight trucks will continue to operate for the minimum transport of goods and people.

Table 5 Assumptions for impact on energy demand for automobiles

Vehicle type	Impact	Assumption
Private vehicles	Down 80%	Voluntary stay-at-home except for essential purposes.
Taxis	Down 80%	Voluntary stay-at-home except for essential purposes.
Buses	Down 70%	Tourist buses are suspended. Minimum transport secured for commuting to work, visiting hospitals, etc.
Freight vehicles	Down 50%	There is demand for the delivery of goods such as food and other daily necessities, and mail and parcel delivery.
Motorcycles	Down 50%	There is demand for transport such as for delivery of parcels, food, and mail.

Results of the calculation

Based on the assumptions above, we calculated the impact on energy demand depending on the size of population under “lockdown”. The impact was calculated for each day, so the impact would be greater if the lockdown is protracted.

The energy which saw the greatest impact on demand was oil products including car fuel, accounting for most of the decline in demand in our calculation (Fig. 1). In particular, the voluntary restraint on using private vehicles will significantly affect gasoline demand. For example, in a “lockdown” of a city with 10 million people, which is the largest population case included in our

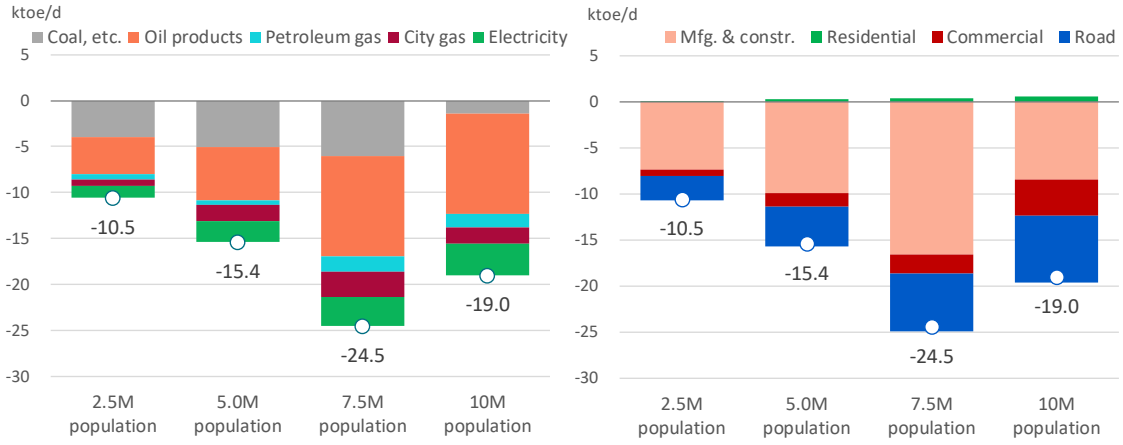
calculation, energy demand would fall by 19,000 tonnes of oil equivalent per day, of which 57% is attributable to the decline in demand for oil products for automobiles and manufacturing. Incidentally, a decline of 19.0 ktoe (ktoe: 1,000 tonnes of oil equivalent) in demand corresponds to 36% of the final energy consumption for a city of this size (Fig. 2). The demand for oil products will decline by 13,800 kl per day (or 86,800 B/D, with approximately 70% of the fall attributable to gasoline and diesel oil for automobiles). This is equivalent to a 50% decline in oil products consumption for a city of this size.

Demand for coal (and others) and Electricity will see the second largest impact. The impact on industrial energy, especially on coal, etc., will vary significantly depending on the presence of large factories. Moreover, the impact on electricity demand grows with the size of the city due to the shutdown of offices which consume relatively large amounts of electricity. For example, in a "lockdown" of a city with around 10 million people, electricity demand would fall by 39.30 GWh (accounting for 18% of the fall in overall energy demand), equivalent to 25% of electricity demand for a city of this size. Meanwhile, electricity demand of households will increase only modestly and have only a small impact on energy demand change.

By size of population, energy demand for residential/commercial and transportation use increases mostly in proportion to population. Meanwhile, for the manufacturing industry, the impact is higher in cities with 5.0–7.5 million people as factories, especially large ones, are located in the suburbs. As a result, the impact on energy demand as a whole is the greatest in cities with a population of 7.5 million in our calculation (Fig. 1). Further, as shown by the case of the Tokyo Metropolitan area, the impact on energy demand for business tends to be greater than the city's population as cities with large populations normally have a high concentration of commercial businesses. Meanwhile, cases for regional cities show that cities with a smaller population tend to have a relatively higher rate of car ownership per population and hence, the impact on energy demand for cars is relatively greater.

Depending on the situation, a "lockdown" could be enforced over an area larger than the respective case of the cities considered in this calculation. While not illustrated in this paper, if, for example, the assumptions for this calculation are applied to a "lockdown" of a "city areas" with 30 million people, the fall in overall energy demand would reach 83 ktoe per day, equivalent to 10% of Japan's final energy consumption. In that case, the demand for oil products would fall by 48,600 kl per day (306,000 B/D), a significant decline equivalent to 11% of Japan's total energy demand.

Fig. 1 Estimated impact of a city "lockdown" on energy demand



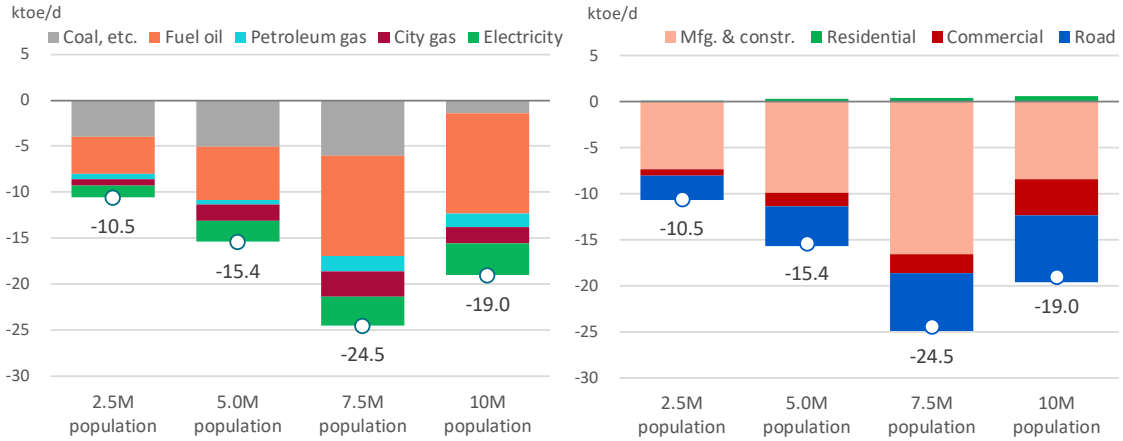
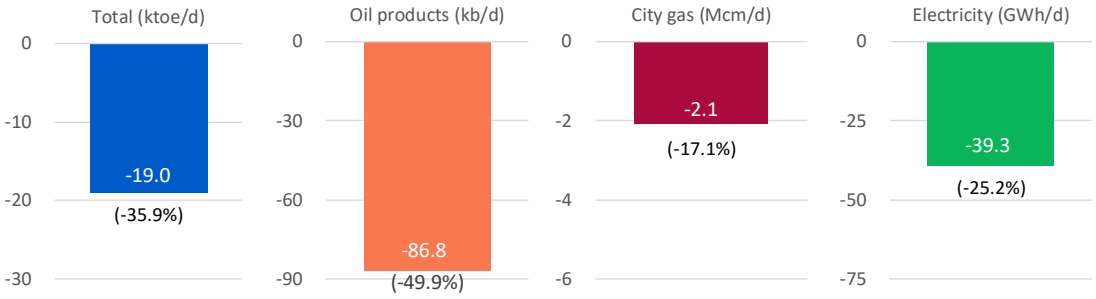


Fig. 2 Estimated impact of "lockdown" on energy demand: city with a population of 10 million



Note: The percentage in parentheses is the change from the estimated average sales per day in 2019.

Conclusion

Based on the described assumptions and prerequisites, the estimations showed that a "lockdown" would result in a significant drop in energy demand, mainly for oil products such as gasoline and diesel oil. The decline will naturally expand if a larger population is placed under "lockdown", as will its impact on the energy market. In this study, the possible decline in energy demand under a "lockdown" was calculated on a per-day basis. Therefore, for actual energy markets and energy industries, the duration of the "lockdown" and the resulting impact on the total amount, as well as these per-day values, are also important factors.

Finally, it should be noted that there are limits on the availability of data for the energy demand of large cities, there is significant uncertainty as to the kind of restrictions that might be imposed in a "lockdown" and how rigorously they would be enforced, and the calculations in this estimate were performed based on certain prerequisites and conditions in view of these uncertainties. Further, this estimate assumes that the "lockdown" takes place in April; if imposed in summer or winter, the calculation results would be different due to the factors such as the impact of air conditioning. Our estimates need to be refined by taking these points into account and performing further analyses using more detailed data and by reflecting the situations of actual lockdowns.

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