The Benefits and Issues of the “Stop-Count” Measure on Existing Japanese Nuclear Reactors

Kenji Kimura, Senior Researcher, Nuclear Energy Group
Tomoko Murakami, Group Manager

1. Introduction

Amid indications of the importance of nuclear power from the viewpoint of climate policy, electricity supply stability and energy security, major developments in the debate over nuclear power policy in Japan were seen in the second half of 2022. In particular, at the meeting of Ministry of Economy, Trade and Industry’s Nuclear Energy Subcommittee on December 8, the *Agenda for the future direction and realization of nuclear power policy (draft)* was presented, with basic principles laid out for handling various challenges in nuclear power policy. These principles, which are to be included in the basic policy of the GX (Green Transformation) Implementation Council[1] chaired by the Prime Minister, were approved by the members of the subcommittee.

Of the measures in the draft agenda above, one of the most likely to have a specific impact in the relatively near future is seen to be the implementation of a new rule related to the operating life of existing reactors. In this paper, were the draft agenda to be approved, we estimate the potential impacts on operating life extensions for existing reactors and endeavor to identify the challenges that might arise.

2. Debate over operating life extensions

Under the current rules that were established in the wake of the Fukushima Daiichi Nuclear Power Plant accident (hereafter “Fukushima Daichi accident”), all nuclear reactors were permitted to operate for 20 further years, once only and on condition of passing a prescribed safety inspection, based on a basic operating life of 40 years from the date of their entry into operation[2]. Nevertheless, Japan’s nuclear power plants, which all suspended operations after the Fukushima Daichi accident, were required to pass the safety inspection of the Nuclear Regulation Authority. Due to the prolonged period of these inspections, 23 of 33 existing reactors have not yet been able to restart operations as of December 2022, more than 10 years on from the accident. Moreover, some plants that have restarted have been forced to suspend operations due to failure to meet deadlines for new antiterrorism specialized safety facilities required to meet the regulations, and in many parts of Japan

[1] GX Implementation Council, *Basic Policy of GX (Draft)*, December 22, 2022.
[2] See Kimura (2021) shows that these rules had had the possibility for revision from their beginning (https://eneken.ieej.or.jp/data/10047.pdf) .

lawsuits from local communities have demanded the suspension of reactor operations. In some cases, courts have handed down rulings stopping plant operations.

As a result of such factors, these nuclear plants are nearing the end of their lives without generating a single watt of electricity as they reach the operating time limits (40 years or 60 years). This situation not only limits our ability to take advantage of the stable power supply and zero-emission performance of nuclear power, it could also have a serious impact on the generation portfolios of power companies that own nuclear power plants. There are also concerns that the highly uncertain business environment could discourage new investment in nuclear power. Therefore, the recently announced draft agenda includes a proposal to deduct the period of suspension due to inspections or other reasons from the prescribed operating life and extend the operating life by that amount of time (hereinafter referred to as "stop-count"). The impact of implementing this proposal will be estimated in the next section.

3. The impact of the stop-count

The rules in the draft agenda related to the stop-count are as follows[3].

A：Shutdown periods resulting from regulatory changes (safety rules, etc.) made after the Great East Japan Earthquake disaster (including inspection and preparation periods following changes in circumstances)

B：Shutdown periods resulting from administrative orders, advice or guidance, etc. after the Great East Japan Earthquake disaster (excluding suspensions due to inappropriate conduct by the plant operator)

C：Shutdown periods resulting from provisional court orders or other reasons unforeseen by the plant operator after the Great East Japan Earthquake disaster (limited to those cases where remedy is gained in higher court)

Based on these rules, the authors set certain conditions and estimated the stop-count period[4],

[3] Agency for Natural Resources and Energy. *Agenda for the future direction and realization of nuclear power policy (draft)*, 35th meeting of Nuclear Energy Subcommittee, Electricity and Gas Industry Committee, Advisory Committee for Natural Resources and Energy, December 8, 2022.

[4] The authors set the main conditions as follows:

・In addition to the period from shutdown to restart after the Fukushima Daiichi accident, the calculation includes any suspensions required for completion of specialized safety facilities and to abide by court rulings.

・For plants that had been out of service prior to the Fukushima Daiichi accident, the shutdown date is set as March 11, 2011.

・For plants that have not restarted as of the time of writing (April 2023), for the purposes of calculations in this paper, it is assumed that their restart date shall be December 31, 2023 (because it is unlikely that they will be restarted within this year judging from their current state). However, the dates of expected conclusion of regular inspections are shown for Reactors 1 and 2 of KEPCO Takahama Power Station, therefore this information is included in the calculation (applying the condition below at the same time, it is assumed that restart will occur one month after the

with the results shown in Table 1. The total stop-count period for all 33 reactors is 357.3 reactor-years, at an average of 10.8 years for each reactor. If it had been possible to operate normally[5] during this period, the power output of those reactors would have been about 2,200 TWh (total power generation in Japan 2021 was about 1,000 TWh[6]). At a unit price of 13.5 yen/kWh[7], the average wholesale electricity market price in FY2021, the value of the power (the product of the amount of power and the unit price) lost due to the shutdown totaled about 30 trillion yen. Of course, since the price of electricity constantly changes depending on the situation, this amount is only a rough indication, but this is considered to be the total amount that can be expected to be obtained by stop-count and would be a considerable incentive for power companies. In addition, if all of this power generation replaced LNG thermal power generation (combined cycle), carbon dioxide (CO_2) emissions have been reduced by 997 million tons[8]. This is higher than total Japan's CO_2 emissions from energy sources (967 million tons[9]) in FY2020.

Table 1. Stop-count periods for each plant

Restarted & Expected			Restart not yet determined					
Plant name	Installed capacity (GW)	Shutdown period (years)	Plant name	Installed capacity (GW)	Shutdown period (years)	Plant name	Installed capacity (GW)	Shutdown period (years)
Mihama 3	0.83	11.1	Tokai-II	1.10	12.8	Kashiwazaki-Kariwa 5	1.10	11.9
Takahama 1	0.83	12.3	Tsuruga 2	1.16	12.7	Kashiwazaki-Kariwa 6	1.36	11.8
Takahama 2	0.83	11.7	Tomari 1	0.58	12.7	Kashiwazaki-Kariwa 7	1.36	12.4
Takahama 3	0.87	6.6	Tomari 2	0.58	12.4	Hamaoka 3	1.10	12.8
Takahama 4	0.87	6.5	Tomari 3	0.91	11.7	Hamaoka 4	1.14	12.6
Ohi 3	1.18	6.4	Onagawa 2	0.83	12.8	Hamaoka 5	1.38	12.6
Ohi 4	1.18	5.8	Onagawa 3	0.83	12.8	Shika 1	0.54	12.8
Ikata 3	0.89	8.3	Higashidori 1	1.10	12.8	Shika 2	1.21	12.8
Genkai 3	1.18	8.2	Kashiwazaki-Kariwa 1	1.10	12.4	Shimane 2	0.82	11.9
Genkai 4	1.18	7.1	Kashiwazaki-Kariwa 2	1.10	12.8			
Sendai 1	0.89	5.1	Kashiwazaki-Kariwa 3	1.10	12.8			
Sendai 2	0.89	4.9	Kashiwazaki-Kariwa 4	1.10	12.8			

Source: Calculated by the authors from Agency for Natural Resources and Energy documents, among others (installed capacity from Japan Atomic Industrial Forum (2022)[10])

dates of expected conclusion of the regular inspection).

・For plants that have already restarted operations, the restart date is defined as that of resumption of commercial operation. This is the same as for those plants coming back from suspensions related to specialized safety facilities or court rulings. For plants that did not have a specified commercial operation restart date as of the time of writing, the date of resumption of commercial operation is defined as one month after the restart of power generation.

[5] At a capacity utilization rate of 70%. This was the track record of operation in Japan before the Fukushima Daiichi accident.

[6] From IEA statistics.

[7] Agency for Natural Resources and Energy. *Recent trends in the wholesale electricity market*, 49th meeting of the Electricity and Gas Policy Subcommittee, Electricity and Gas Industry Committee, Advisory Committee for Natural Resources and Energy, May 17, 2022.

[8] CO_2 emission factors by power generation source are from Japan Atomic Energy Relations Organization, *Graphical Flip-chart of Nuclear & Energy Related Topics*.

[9] From the website of the Greenhouse Gas Inventory Office of Japan.

[10] Japan Atomic Industrial Forum, *World Nuclear Power Plants 2022*, 2022.

4. Discussion

As seen in the previous section, stop-count is a measure that could contribute to electricity supply to Japan and carbon emission reduction and be a considerable incentive for power companies, but there are several considerations that would need to be taken into account in practice. The first are the issues involved in specific system design, such as how to calculate the number of days to be deducted. This paper raises broadly three main points here. We would also like to point out the respective implications of the adoption of stop-count for plants that have already been restarted, that have not yet restarted, and that are to be decommissioned.

4.1 Methodology for calculating shutdown period

(1) Start date of the shutdown period to be deducted

In our study, the start date of the shutdown period for the nine plants that were already stopped prior to the Fukushima Daiichi accident due to regular inspections or equipment issues is set as March 11, 2011. For example, Kashiwazaki-Kariwa Nos. 3 and 4 were already in long-term outage at the time of the Fukushima Daiichi accident due to the 2007 Chūetsu offshore earthquake. In terms of these plants, further consideration is likely to be needed in future as to whether their full shutdown period from March 11 should be seen as due to the Fukushima Daiichi accident.

(2) End date of the shutdown period to be deducted

Since the official start of operation is generally considered to be the start of commercial operation, this paper sets the end date of the shutdown period (that is, the date of operation resuming) as the date of resumption of commercial operation. However, if the date is set as the day the reactor is restarted or the date of power generation resumes, the shutdown period subject to the stop-count is inevitably shortened. Since neutron irradiation embrittlement of a nuclear reactor is caused by the operation of the reactor, if we were to emphasize this point, we might consider the end date of the shutdown period to be the day of reactor restart. However, it should be noted that this measure is intended to stipulate the period of use of nuclear reactors from the perspective of nuclear energy policy. Measures to evaluate the deterioration of equipment from a scientific point of view are to be implemented separately by the Nuclear Regulation Authority (see below).

(3) Shutdowns due to regular inspections from prior to the completion deadline for specialized safety facilities

Takahama No. 3 and Genkai No. 3 were shut down for regular inspections about seven

months earlier than the actual completion deadline. In this study, it is deemed that the work necessary for the construction of specialized safety facilities was underway even before the deadline (that is, the shutdown period necessary for the construction of the specialized safety facility), and these are also included as stop-counts. However, in the case of Takahama No. 3, which was scheduled to resume operations ahead of the deadline for the specialized safety facility, the regular inspection was postponed due to damage to the steam generator heat transfer tube, and as a result, the deadline for its specialized safety facility passed in August 2020. In addition, Genkai No. 3 was originally scheduled to complete its specialized safety facility by a deadline of August 2022, but it was reported that the construction period was extended due to a fire at the construction site and the impact of COVID-19[11]. The reactor resumed operation in December 2022. If rigorous calculations are to be made in these cases, it is necessary to clarify how many days of the shutdown period are due to work related to specialized safety facilities. In the case of Genkai No. 3, it may be a point of issue whether the cause of the delay is attributable to the operator.

Given that operators are responsible for failure to meet deadlines in completing their specialized safety facilities, it might also be reasonable not to include specialized safety facility issues in the stop-count.

4.2 Implications of stop-count for plants that have already been restarted, that have not yet restarted, and that are to be decommissioned

Defining the actual age of a plant as the period from the start date of its commercial operation to December 31, 2023 (see footnote 4), the age after the application of the stop-count can be obtained by deducting from that age the number of years of shutdown as calculated in Table 1. The actual age of each plant and the age after applying stop-count are summarized in Figure 1. As shown in the figure, unrestarted plants tend to be "young" plants because more years are deducted from their age than plants that have been restarted or are expected to be restarted. Therefore, although it is currently unclear whether the final operating life of each plant will be 40 years or 60 years, the remaining operating life will clearly be longer for the unrestarted plants. Of course, according to this method, there is no significant difference between restarted plants and unrestarted plants in terms of total operating time. On the other hand, it should be noted that under the stop-count measure, the remaining life will be shorter for plants that are restarted earlier, are equipped with superior technological capabilities, and are in compliance with the new regulatory standards. The current stop-count proposal can be seen as a "relief measure for plants that had to shut down for a long time due to external factors that could not have been foreseen by the operator,"

[11] *Saga Shimbun*, December 6, 2022.

but it may be necessary to acknowledge the achievements of the plants that have carved a path to restart with few (or no) precedents and the importance of the efforts they made to get there.

Moreover, stop-count may have economic profit for remaining plants, but of course it is not valid for those reactors permanently closed and already scheduled for decommissioning. Some decommissioning decisions made since the Fukushima Daiichi accident have been reached by comparing the forecast costs involved in restarting with the forecast profits from their remaining operating period after achieving restart[12]. If stop-count had been in place then, it may have had an influence on decisions about the survival of plants.

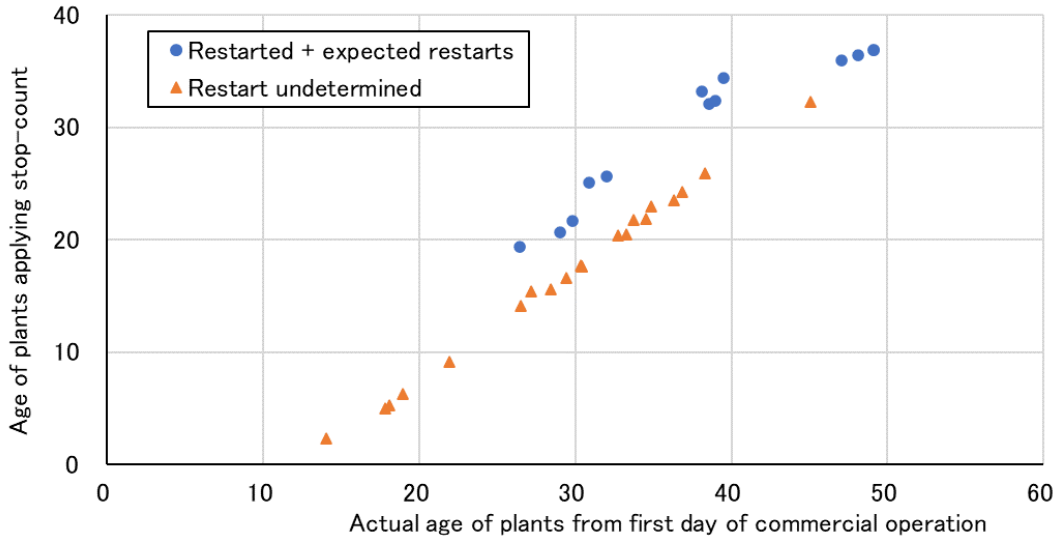

Figure 1. Actual age of plants and age after the application of stop-count

Source: Calculated by the authors from Agency for Natural Resources and Energy documents

5. Conclusion

In this study, shutdown periods that might be subject to stop-count measures based on the content of the *Agenda for the future direction and realization of nuclear power policy (draft)* were calculated, the impact demonstrated and potential issues arising in implementation raised. As a measure to promote the utilization of existing reactors, stop-count would be a considerable incentive for nuclear power companies, but at this time there are a number of matters to consider. If the measure were implemented, it would need to be given more detail in a logical, explicable form.

It must also be noted that some facilities age even during shutdown periods. The "stop-

[12] For example, the reason stated for the decision to decommission Ikata No. 2 taken in March 2018 by Shikoku Electric Power was, “Taking into account all of the factors such as operating period from restart and output, we have decided to decommission it” (Shikoku Electric Power press release, March 17, 2018).

count" theory discussed in this paper is intended to define the period of use of nuclear reactors from the perspective of nuclear energy policy. It does not include the perspective of ensuring safety. In this regard, the Nuclear Regulation Authority has announced a policy of conducting inspections 30 years after the start of operation, with further inspections every 10 years thereafter as a new mechanism for periodically determining whether or not to continue operation of a reactor[13]. This policy was determined by the Authority and is under Diet deliberations at the same time as the stop-count measure as of the time of writing. If it does not pass the inspection by the Authority, it would not be possible to continue operation at that point, regardless of the operating life extension afforded by the stop-count[14]. It is important to grasp the impact of aging through such a check mechanism in the effective use of existing reactors over the long term.

Contact: report@tky.ieej.or.jp

[13] Nuclear Regulation Authority Chair Scheduled Briefing paper, *Safety regulatory system related the aging of reactors (current and proposed)*, December 21, 2022.
Note that a mechanism to assess aging is already in place at 30 years after the start of operation, with further inspections every 10 years thereafter. This proposal brings together the decision on continuing operation and the aging assessment.

[14] Also considered by the Nuclear Energy Subcommittee was a proposal for government to not set a particular ceiling on operating period, so that continued operation could be decided by the Nuclear Regulation Authority from the viewpoint of safety (Agency for Natural Resources and Energy. *Matters for future consideration related to nuclear power policy*, 33rd meeting of Nuclear Energy Subcommittee, Electricity and Gas Industry Committee, Advisory Committee for Natural Resources and Energy, November 8, 2022).