PERMANENT CESSATION OF TOKAI POWER PLANT'S OPERATION

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Abstract

Tokai power plant (166MWe, Magnox type: GCR) is the first commercial reactor in Japan and has been kept operating stably since its commissioning in July 1966. During this period it has produced electricity of approximately 27.7 billion KWh (as of March 1997) and its stable operation has contributed greatly to the stable supply of electricity in Japan.

Furthermore, technologies in various fields have been developed, demonstrated and accumulated through the construction and operation of Tokai power plant. It also contributes to training for many nuclear engineers, and constructions and operations of nuclear power stations by other Japanese power companies. As a pioneer, it has been achieved to develop and popularize Japanese nuclear power generation.

On the other hand, Tokai power plant has small capacity in its electric power output, even though the size of the reactor and heat exchangers are rather bigger than those of LWR due to the characteristics of GCR. Therefore, the generation cost is higher than the LWR. Since there is no plant whose reactor type is the same as that of Tokai power plant , the costs for maintenance and fuel cycle are relatively higher than that of LWR.

Finally we concluded that the longer we operate it, the less we can take advantage of it economically.

As a result of the evaluation for the future operation of Tokai power plant including the current status for supply of electricity by the Japanese utilities and study of decommissioning by Japanese government, we decided to have a plan of stopping its commercial operation of Tokai power plant in the end of March, 1998, when we completely consume its fuel that we possess.

From now on, we set about performing necessary studies and researches on the field of plant characterization, remote-cutting, waste disposal for carrying out the decommissioning of Tokai power plant safely and economically. We are going to prepare the decommissioning planning for Tokai power plant in a few years based on the guideline recommended by the government and on the situation of establishment of relevant criteria under the consultation and coordination with the government, local communities, utilities and relevant organisations.

1. Introduction

Tokai Power Plant (166MWe, Magnox type GCR) of the Japan Atomic Power Company (JAPC), the first commercial nuclear power plant in Japan, started its operation in 1966. Since then, construction of commercial nuclear power plants has been promoted in Japan. The number of operating nuclear power plants as of August 1997 is 52 and total capacity is 45.1 GWe. Electricity generation by nuclear power amounts to 34.0 % of all commercial electricity generation in fiscal year 1996. Thus, nuclear power is now an essential power source in Japan.

In Japan, where natural resources for energy is not rich, nuclear power is planned to continue to develop in future as well. It is planned to develop up to 70 GWe by the year 2010.

JAPC decided in June 1996 to stop operation of Tokai Power Plant at the end of March 1998, because of economical reasons such as increase of the operating cost and the outlook of the maintenance cost. Tokai Power Plant is the only gas-cooled reactor in Japan. Light water reactors are dominant in nuclear power generation in Japan and have been operated in 13 years on average; see Figure 1. The decommissioning of the light water reactors are not expected for the time being, but the decision on Tokai Power Plant implies that the time will come for the decommissioning of LWRs at any rate.

JAPC has not yet decided the definite programme of decommissioning of Tokai Power Plant and will decide it during the defuelling period. JAPC is now promoting the investigations on decommissioning scenario and technology in accordance with Japan's basic policy on decommissioning.

In the earliest case, defuelling of Tokai Power Plant will be over in the year 2001 and the notification of the decommissioning plan is to be submitted to the Government at this time. The Government and JAPC are developing necessary regulatory arrangements and decommissioning engineering procedures, and they are expected to be completed prior to the notification.

2. Decommissioning Policy in Japan

2.1. Basic Policy for Decommissioning in Japan

The basic policy for decommissioning[1], decided by the Japanese Government (Atomic Energy Commission), is that nuclear reactors should be

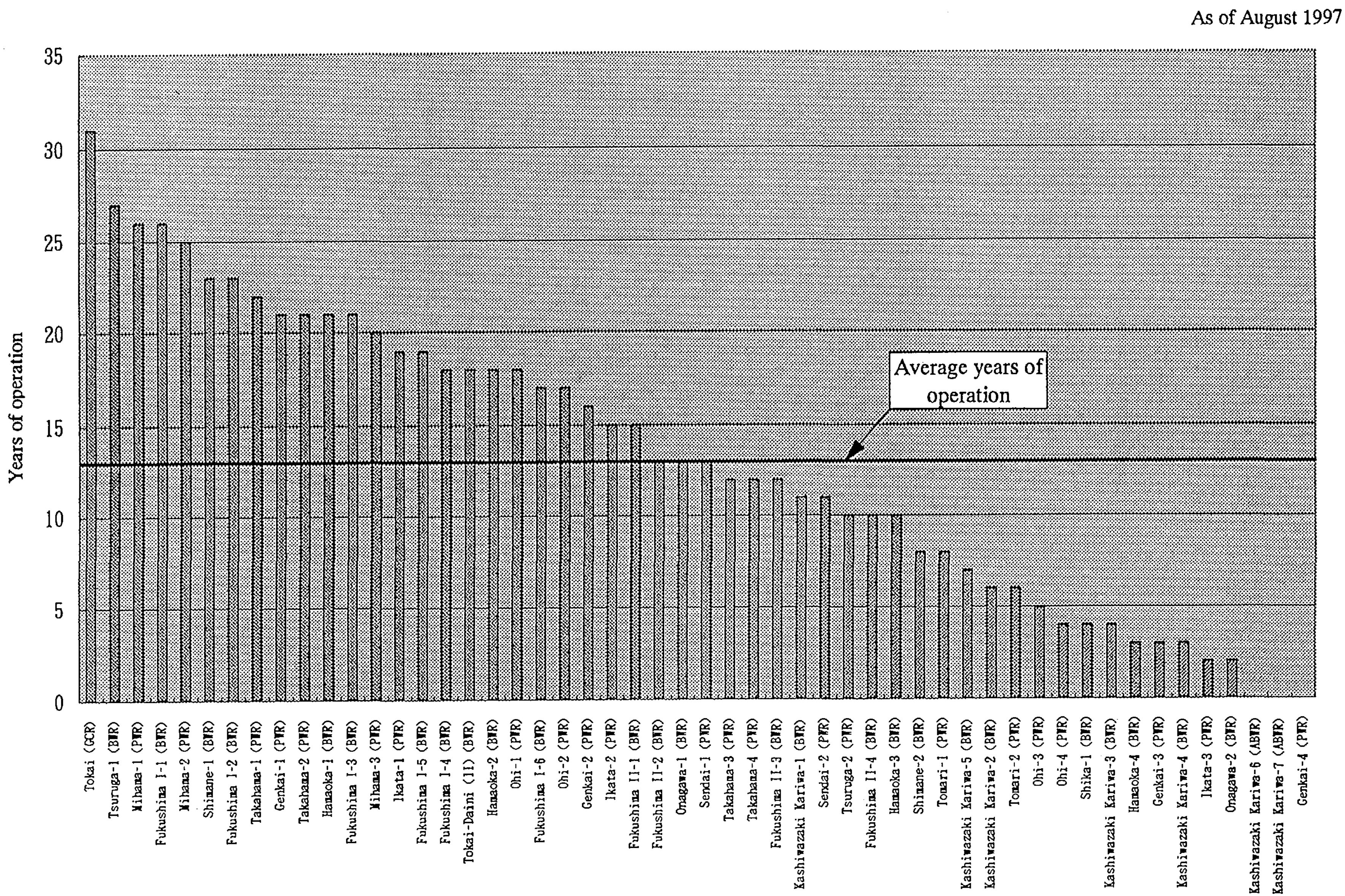

Fig.1. Years of operation of nuclear power plants in Japan [5]

dismantled and removed, in principle, in early phase after termination of operation and the site should be re-used for nuclear power generation, as available areas for sites of nuclear power plants are limited in Japan.

With regard to procedure for decommissioning, the Subcommittee on Nuclear Energy of the Advisory Committee for Energy had recommended (in 1985) the standard process for decommissioning[2], considering the actual Japanese situation. The standard process consists of three stages, that is; system decontamination, safe storage (of about five to ten years) and dismantling.

2.2. Regulatory Issues

In order to perform decommissioning of commercial nuclear power plants, there remains several regulatory issues to be established by the Government and these issues are now being deliberated[3].

(a) Rules for safety affirmation for decommissioning

The regulatory procedures in Japan will be controlled through the notification of decommissioning plans and revision of safety technical specifications. However, it is necessary to define formats and contents of these documents, as there is no experience of actual application for the decommissioning of commercial nuclear power plants. It is also necessary to prepare basis and criteria in order to review an application. The Government is planning to implement a standard format of decommissioning plans and revised technical specifications by the year 2001, when the defuelling of Tokai Power Plant will be finished at the earliest and the decommissioning plan will be submitted.

(b) Issues relating to disposal of decommissioning wastes

In the existing regulatory system, arrangements are not prepared sufficiently for all the low level wastes. Especially, regarding high β/γ low level radioactive wastes, such as reactor internals, (some of them are classified as ILW in some countries), the concept of disposal should be clarified and its regulatory system should be prepared. The Government (Atomic Energy Commission) is now deliberating this issue.

Furthermore, regarding the wastes which are not required to be treated as radioactive wastes, the clearance level is not decided in Japan. The Government (Nuclear Safety Committee) is deliberating to establish a clear criteria, referring to criterion in other countries and the international organisations.

These activities are planned to be completed by the year 2001, when defuelling at Tokai Power Plant will be finished at the earliest (and the notification of its decommissioning plan will be submitted to the Government from JAPC.)

Decommissioning wastes contain a lot of wastes which can be utilised as resources. In order to reduce the influence on the environment, the effective re-use of these wastes is also very important. Various organisations are now performing the research work on this issue.

(c) Reserve fund system for the decommissioning expense

In Japan, the Reserve Fund System for the Decommissioning of Nuclear Power Plants was established in 1988 in order to secure necessary funds for decommissioning, and the fund for each plant has been reserved every year by each utility for the expenses necessary in future.

In this system, the funds for dismantling are included, but disposal costs for decommissioning wastes are not. The method for estimation of disposal cost should be established in accordance with the above establishment of regulatory system for disposal, and the disposal costs are to be reflected to the reserve fund system in future.

3. Tokai Power Plant

3.1. Role of Tokai Power Plant

Tokai Power Plant is the first commercial nuclear power plant in Japan and has kept steady operation since its commissioning in July 1966. It has produced electricity of approximately 27.8×10^9 KWh (as of March 1997) and its steady operation has contributed greatly to the stable supply of electricity in the Tokyo metropolitan area.

TABLE 1. GENERAL DATA OF TOKAI POWER PLANT

Power Output	Thermal	587 MWt
	Electrical	166 MWe
Moderator		Graphite
Coolant		Carbon dioxide gas
Fuel		Natural uranium (MAGNOX can)
Reactor Core	Height	About 7m
	Effective diameter	About 12 m
	Fuel (Initial loading)	186.6ton, 16,348 elements
	Moderator	920ton, 17,912 bricks
Pressure Vessel		
	Material	Carbon steel
	Inner Diameter	About 18 m
	Thickness	About 90 mm
	Weight	About 700 ton
Biological Shield		
	Inner Diameter	About 22 m
	Thickness of Concrete	Max. about 3 m (at upper primary shield floor)
		About 2m (at primary shield wall)
	Total Weight	About 13,000 ton
SRU		
	Number	4
	Total Height	About 25 m
	Inner Diameter	About 6 m
	Weight	750 ton per one SRU
Charge Machine		
	Number	2
	Total Height	About 17 m
	Outside Diameter	2.5 m, at the main pressure vessel
	Weight	600 ton per one charge machine

TABLE 2. DECOMMISSIONING WASTES AND SITUATION OF REGULATORY ARRANGEMENTS

<table>
<tr><th colspan="3" rowspan="2">Classification</th><th rowspan="2">Method of Disposal</th><th colspan="2">Ratio of Wastes from Dismantling</th><th colspan="2">Establishment of Regulatory Systems</th></tr>
<tr><th>1,100MW LWR (500-550 ktons)</th><th>166MW GCR (160 ktons)</th><th>Upper Limit of Activities in Waste</th><th>Technical Standard</th></tr>
<tr><td>I</td><td rowspan="4">LLW</td><td>Hi β γ</td><td>to be established</td><td>less than 0.1%</td><td>2%</td><td>to be established</td><td>to be established</td></tr>
<tr><td rowspan="3">II</td><td>Uniform Solidified</td><td rowspan="3">Concrete Pit (Shallow Land Burial)</td><td rowspan="3">less than 1 %</td><td rowspan="3">8 %</td><td>established</td><td>established</td></tr>
<tr><td>Miscellaneous Solid</td><td rowspan="2">established</td><td>established</td></tr>
<tr><td>Large Scale Metal</td><td>measures for closing holes</td></tr>
<tr><td rowspan="2">III</td><td rowspan="2">ELLW</td><td>Concrete</td><td rowspan="2">Trench (ditto)</td><td rowspan="2">1 - 2 %</td><td rowspan="2">5 %</td><td rowspan="2">to be established</td><td rowspan="2">to be established</td></tr>
<tr><td>Metal</td></tr>
<tr><td rowspan="2">IV</td><td colspan="4">Clearance Level</td><td colspan="2">to be established</td></tr>
<tr><td colspan="2">Non RAW</td><td>as Industrial Waste</td><td>98 - 99 %</td><td>85 %</td><td colspan="2">N/A</td></tr>
</table>

(Remark)

1. In case of LWR.

   ASSUMPTION: ① Power operation period of 40 years. ② Safe storage period of 5 years. ③ Clearance Level based on IAEA TecDoc.[4]
   ④ Consideration of system loops decontamination.

2. In case of GCR.

   ASSUMPTION: ① Power operation period of 30 years. ② Safe storage period of 5 years. ③ Clearance level based on IAEA TecDoc.[4]

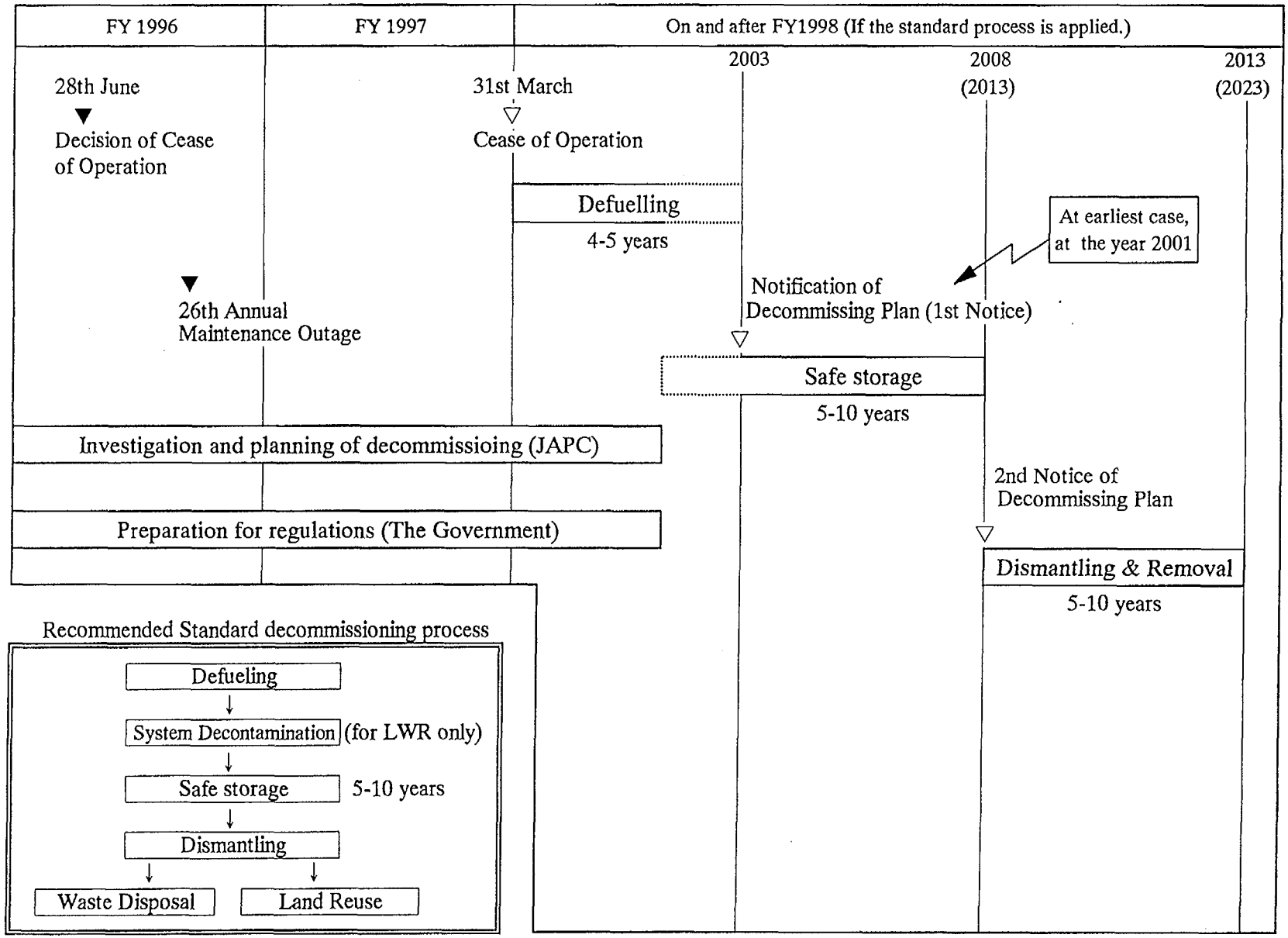

Fig.2. Programme of Decommissioning of Tokai Power Plant (Tentative)

Technologies in various fields has been developed, demonstrated and accumulated through the construction and operation of Tokai Power Plant. It has also contributed to training for many nuclear engineers in other Japanese power companies and industries who have contributed to constructions and operations of nuclear power stations. As a pioneer, Tokai Power Plant has contributed to the development of nuclear power generation in Japan.

3.2. Reason of cessation

Tokai Power Plant has a small capacity in its electric power output, even though the size of the reactor and heat exchangers are rather big, compared with LWRs of the same capacity, due to the characteristics of GCR. Therefore, the generation cost is higher than LWRs. And as there is no plant whose reactor type is the same as that of Tokai Power Plant in Japan, the costs for maintenance and fuel cycle are relatively higher than that of LWRs. It was concluded that the longer we operate it, the less we can take economical advantage of it.

As a result of the evaluation for the future operation of Tokai Power Plant, including the current status for supply of electricity by the other Japanese utilities and the study of decommissioning by Japanese government, we decided to have a plan of stopping its commercial operation of Tokai Power Plant in the end of March 1998, when we completely consume its fuel that we possess.

3.3. Plan after shutdown

After cease of its commercial operation, defuelling will be carried out within four to five years and the fuels will be transported to the reprocessing plant in the UK. The definite plan after defuelling is not decided. (See Figure 2.)

From now on, we set about performing necessary studies and researches on the field of plant characterisation, remote cutting and waste disposal, for carrying out the decommissioning of Tokai Power Plant safely and economically. We are going to prepare the decommissioning plan for Tokai Power Plant in a few years based on the standard process recommended by the government and on the situation of establishment of relevant criteria under the consultation and co-ordination with the government, local communities, utilities and relevant organisations.

We are now preparing the defuelling procedures, and also planning to reduce the frequency and extent of maintenance work and man-power after the cease of operation. In line with these study, we are preparing the drafts of the revised operating rules and revised annual inspection plans.

4. Present Status on Investigation and Research

Decommissioning has already been carrying out in many research facilities in Japan. In many countries, decommissioning of some commercial nuclear power plants have also been carried out. Therefore, technology for executing decommissioning safely can been said to be established.

There remains no significant technical problems with decommissioning which must be solved. In other words, discussion of decommissioning of commercial power plants has already shifted from the phase of the dismantling methods or safety assurance methods to the phase of system engineering such as the proper combination of technologies or how to implement decommissioning economically.

In this respect, it is necessary to develop technologies for more rational and realistic decommissioning. In Japan, NUPEC (Nuclear Power Engineering Corporation) has almost finished development of various basic technologies and now performing technology development aiming for a rational system for the decommissioning of nuclear power plants.

Based on these circumstances, JAPC has been executing the investigations and researches. Among these activities, "Assessment of radioactive inventory" and "Feasibility study of decommissioning method" are described below.

(1) Assessment of radioactive inventory

Characterisation of radioactive inventory of a plant, including the configuration of nuclides of radioactivity and its distribution in the plant, is vitally important not only for actual decommissioning but also in the stage of preparation of regulatory system and decommissioning plan, together with the data base of the plant, such as information on the structures and materials in detail of each piece of equipment and building.

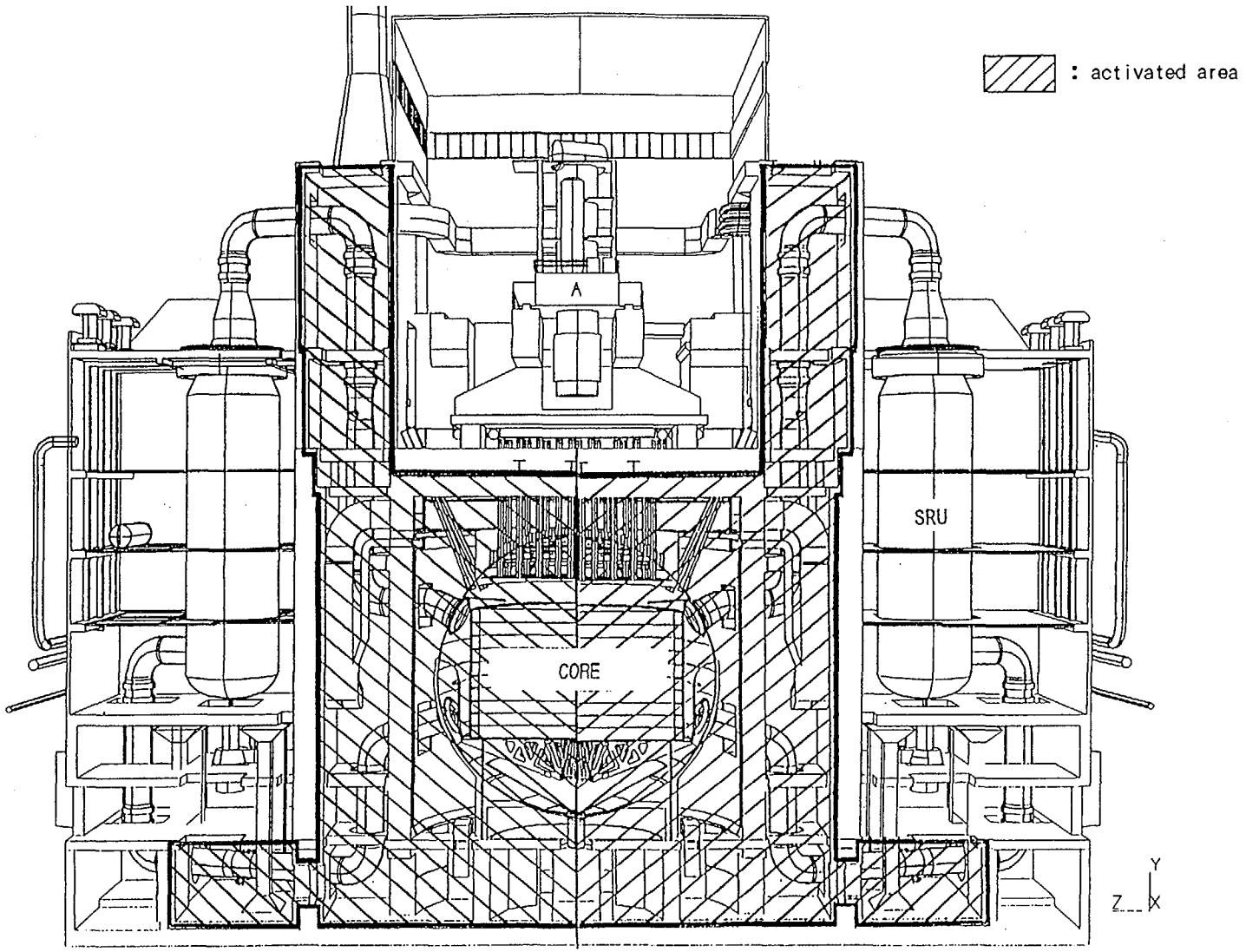

Fig.3 Activated area based on inventory assessment

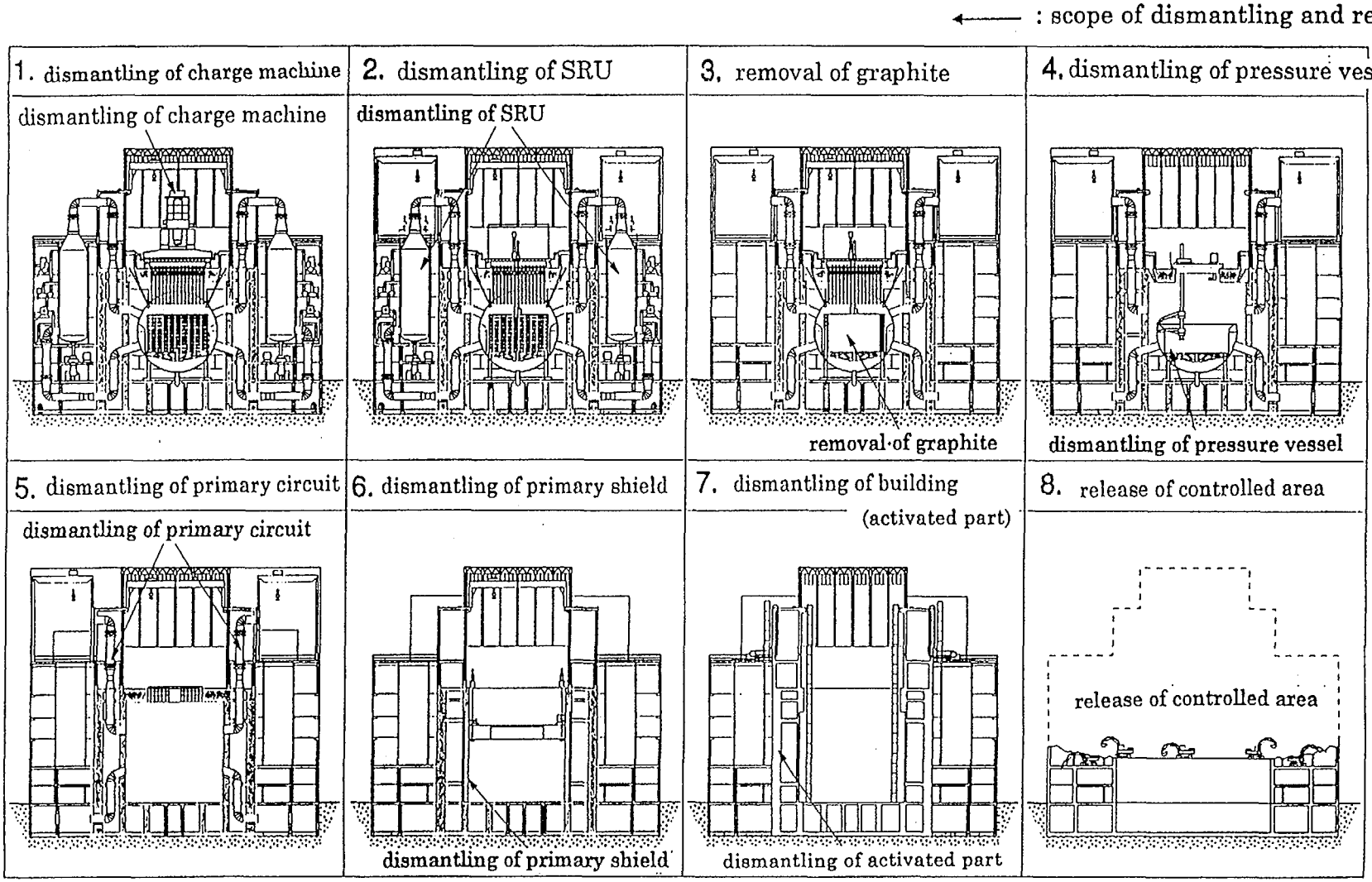

Fig.4 Outline of dismantling process of Tokai Power Plant

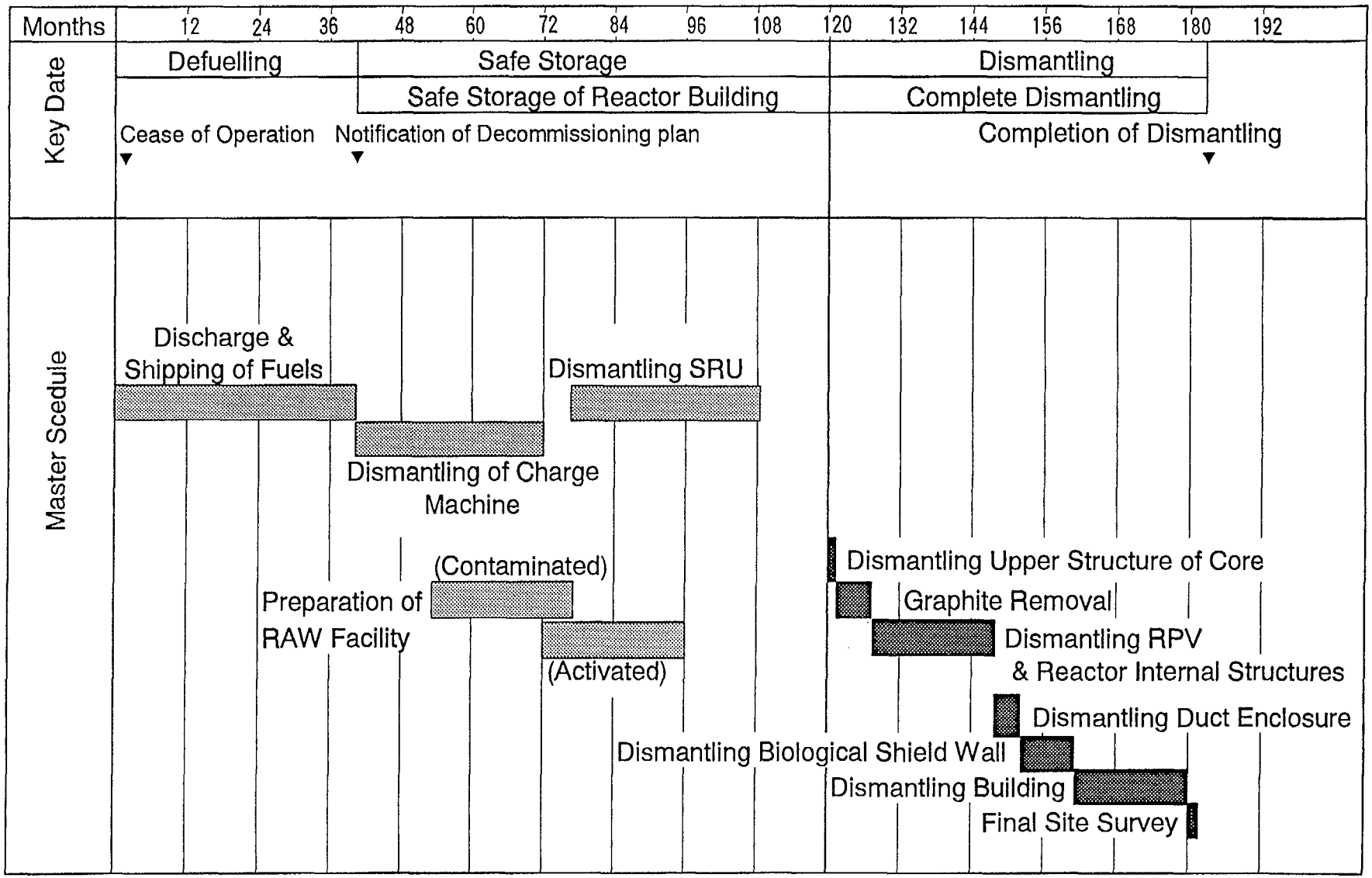

Fig.5 Dismantling programme of Tokai Nuclear Power Plant (for case study)

In Tokai Power Plant, collection of such data has been carried out within the extent that it does not interfere the plant operation, and the data has been accumulated. An example is shown in Figure 3. We think we have to continue these activities further, such as taking the samples which could not be possible during plant operation.

(2) Feasibility study of decommissioning method

The extensive feasibility study on Tokai decommissioning has been carried out. The object of the study is to investigate the methods and procedures which are feasible with more reasonable costs and to find out the points for further cost reductions. The study covers the whole aspects of decommissioning, including the safe storage period and methods, dismantling methods, radioactive waste treatment, packaging of decommissioning wastes, and burial disposal of wastes. From the results of the study, examples of dismantling procedures and programmes are shown in Figure 4 and 5, respectively.

(3) Further R&D

JAPC will focus its efforts on the development of the following technologies from now on:-

① Remote cutting and handling technology (with high autonomy)
② Dismantling method with high efficiency and low cost
③ Decontamination method with less secondary wastes
④ Technology to prevent radioactivity dispersion and technology for collection and treatment of radioactive substances with high efficiency
⑤ Engineering database and engineering system

5. Conclusion

Tokai Power Plant, the first commercial nuclear power plant in Japan, has decided to stop commercial operation in March 1998. However, cease of operation does not mean the immediate start of dismantling. It takes about four to five years for defuelling. Shortening of the period is being investigated. Considering the availability of transportation for the spent fuels to the reprocessing plant in the

UK, it takes at least three years or more. Five to ten years for safe storage is required if it follows the standard process for decommissioning in Japan. As a result, the period of about ten years or more will be necessary before the actual start of dismantling of major facilities. It means that planning for decommissioning should consider technological level and social situation in the future of ten years or more.

Tokai Power Plant will have an important role in Japan to demonstrate that the decommissioning of commercial nuclear power plants, including LWRs, can be executed safely and economically. Therefore, on the planning for its decommissioning, we have to take consideration of the application for LWRs, which are now dominant in the commercial nuclear power generation in Japan.

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