Market Analysis of Medical Radioisotope, Mo-99

Kye Hong Lee [a*], Seung-Kon Lee [a], Ul Jae Park [a], Jun Sig Lee [a]
[a]*Korea Atomic Energy Research Institute, 989-111 Daedeok-daero Yuseong–gu, Daejeon, Korea*
[*]*Corresponding author: khlee@kaeri.re.kr*

1. Introduction

The world market of diagnosis radiopharmaceuticals expects to increase from 1.77 billion USD in 2014 to 3.58 billion USD in 2020, which means 13.1% of annual growth rate [1]. This increase is due to the development of new radiopharmaceuticals, need of early and accurate diagnosis, and more application of nuclear imaging. Due to more cancer patients, better public acceptance on radiopharmaceuticals, better applicability of therapeutic radiopharmaceuticals against the side effects of existing cancer therapies, the world nuclear therapeutic market expects to grow from 0.76 billion USD in 2014 to 1.1 billion USD in 2020. The average growth rate of world radiopharmaceutical market between 2014 and 2020 is 8% while that of Asia-Pacific region is 10.4% [2]. US have a largest market share which is 43% (1,813.4 million USD) of the world market.

Radioisotope (RI) imports in 2015 is 3.82 billion won and that of medical area is 2.63 billion won, which is 68.9% of RI imports. The top 5 RI imports are I-125, Mo-99, Co-60, Ir-192, and I-131 which is 73.6% of all RI imports. The import of Mo-99 is 9.1 billion won which is 23.9% of all RI imports.

Mo-99 is mother nucleus of Tc-99m which is a very important isotope for diagnosis and more than 80% of radiation diagnostic procedures in nuclear medicine depend on this isotope. Late 2008 and in the middle of 2010, the unplanned shutdown of two of the major Mo-99 production research reactors caused a global shortage of Tc-99m, leading to delayed and cancelled medical procedures in Korea. This motivated launching RI production research reactor construction project, KJRR (Kijang Research Reactor) Project in April, 2012.

2. Market Analysis of Mo-99

The existing reactors producing Mo-99 and the future reactors will be investigated and the demand growth rate will be estimated to predict the balance between production and demand. Mo-99 production strategy will be proposed for the self-sustainability of KJRR.

2.1 Mo-99 Productions

Currently, there are 9 reactors producing Mo-99 and 2 reactors expanding production capability (OPAL) or installing production facility (FRM-II), and 1 reactor (NRU) is in standby to produce Mo-99 in the event of significant shortage as shown in Table 1 [3]. NRU will be eventually shut down in 2018. OSIRIS has been already shut down in 2015 and NRU stopped production in 2016. OPAL increased the capacity to 2,150 6-day Ci/week in the 1st quarter of 2017 and eventually to 3,500 6-day Ci/week in the 1st quarter of 2018 to mitigate less capacity due to the stop of OSIRIS and NRU. Three existing global Mo-99 suppliers (ANSTO, Mallinkrodt, and NTP) plan to expand their supply capacities and it would be increased by about 4,400 6-day Ci/week by the end of 2017. This added capacity would almost offset the loss of available supply capacity (4,680 6-day Ci/week) when NRU/Nordion stops producing and supplying Mo-99 after Oct. 31, 2016[4].

Table I. Current Irradiators

Reactor	Mo-99 production weeks per year	Capacity per week (6-day Ci)	Estimated end of operation
BR-2	21	7800	At least until 2026
HFR	39	6200	2024
LVR-15	30	3000	2028
MARIA	36	2700	2030
OPAL	43	2150	2057
RA-3	46	400	2027
SAFARI-1	44	3000	2030
RIAR	50	1000	At least until 2025
KARPOV	48	350	At least until 2025
OPAL	43	+1350 in 2018	2057
FRM-II	32	2100 in 2020	2054
NRU	None scheduled	Up to 4680	2018

Two of the current largest reactors (HFR and BR-2) may close by 2026. Failure to replace their supply by new technologies/reactors could lead to further shortages [5]. The production capacities at the end of 2026 will be 14,700 6-day Ci/week while the demand is 13,526 6-day Ci/week considering 1.2% annual growth rate (red line in Fig. 1) and 35% of an outage reserve capacity. When the growth rate is 7% (brown line in Fig. 1), the production capacities will be far below the demand, 22,337 6-day Ci/week in 2026[5].

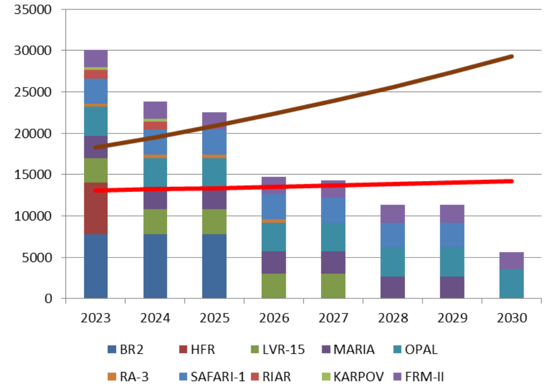

Fig. 1. Projection of Mo-99 supply along with reactors shutdown

The production capacities will be down to 5,600 6-day Ci/week in 2030 with only two reactors remaining and it is inevitable to have new technologies/reactors. Note that the production capacity is the maximum amount that can be produced and normally it cannot be achieved due to the unplanned operational conditions. There are three new reactors under construction or in design stage; JHR in France, RA-10 in Argentina, and KJRR in Korea. The five potential irradiators using natural Mo, enriched Mo, non-fissile, LEU-SGE, or LEU solution are MURR/NorthStar, NorthStar, MURR/GA, and SHINE [3].

2.2 Market Analysis of Mo-99

The Mo-99 price in domestic market was increasing slowly up to 2008 but jumped up from 2009 to 2011 when there was a global shortage. The domestic demand is about 7,300 6-day Ci/yr (140 6-day Ci/week). The import of Mo-99 jumped by 80% from 2009 to 2011 while that of Tc-99m generator was down to 51% from 2007 to 2009. This is due to the domestic production of Tc-99m generator. The annual demand of Mo-99 in Japan is 52,000 6-day Ci (1,000 6-day Ci/week). There is no official statistics on Mo-99 demand in China while it is estimated about 600 6-day Ci/week based on the data for Beijing area. There is no plan to build a research reactor to produce Mo-99 in Japan and it is difficult to predict the date when the first Mo-99 from CARR which is in commissioning in China. Considering the short half-life of Mo-99 (66 hours), the KJRR has a very good price compatibility to export Mo-99 in Asia. Actually, the KJRR can supply Mo-99 to Beijing by 9% less decayed and to Tokyo by 7.3% compared to OPAL in Australia. Also, compared to SAFARI-1 in South Africa, the KJRR can supply Mo-99 to Beijing by 14.5% less decayed and to Tokyo by 16.6%. This means that the KJRR has a good position to play a role as a regional supplier in Asia.

The KJRR can irradiate the targets, produce Mo-99, and process and manufacture Tc-99m generators within the KJRR facility and the target can be delivered to KJRR within a few hours. This makes the price compatibility 20% better than the facility which has different sites for manufacturing targets, target irradiation, processing Mo-99, and manufacturing generators (see Fig. 2).

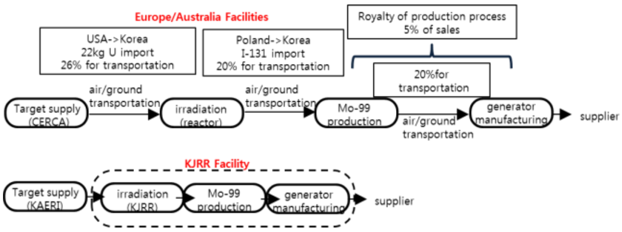

Fig. 2. Mo-99 production facility configuration

Another way the KJRR can promote the Mo-99 export is to establish an alliance with other suppliers. For example, the OPAL and NTP have contracted for backup supply as the Southern Radioisotopes Alliance Inc. The KJRR will advance to the global supplier group and be a part of a global supply chain.

Following nuclear non-proliferation, more reactors are in the process of conversion from HEU to LEU target, which results in the reduction of production yield rate, need of facility modification, and increase of radioactive waste. Together with the outage reserve capacity recommended by OECD/NEA HLG-MR, target conversion causes Mo-99 price increase.

3. Conclusions

Mo-99 is a key radioisotope in nuclear diagnosis procedure and the KJRR project has been launched to secure a domestic supply of Mo-99. It is important for KJRR to export Mo-99 not only to contribute to the global demand but also to maintain the self-sustainability. The prediction of global Mo-99 production capacities to 2030 has been performed. The strategy of KJRR Mo-99 export has been proposed based on the global Mo-99 market analysis.

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