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Are Radioisotope Shortages a Thing of the Past?

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ABSTRACT

Since June 2009, the NEA and its High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) have examined the causes of ^{99}Mo/^{99m}Tc supply shortages and developed a policy approach to address those causes. The NEA has also reviewed the global ^{99}Mo/^{99m}Tc supply situation periodically, using the most up-to-date data from supply chain participants, to highlight periods of reduced supply and underscore the case for implementing the HLG-MR policy approach in a timely and globally-consistent manner. This paper presents the results from a ^{99}Mo/^{99m}Tc capacity and demand forecast, focusing on the potentially critical 2015-2020 period, when major producers in Canada and France are scheduled to exit the market. The modelling results indicate risks to reliable supply of ^{99}Mo/^{99m}Tc globally in the first half of the forecast period (2015-2017), while it is unclear whether new non-reactor-based projects will be able to scale up production on commercial terms and to what degree they will penetrate the market.

1. Introduction

At the request of its member countries, the Organisation for Economic Co-operation and Development (OECD) – Nuclear Energy Agency (NEA) became involved in global efforts to ensure a secure supply of ^{99}Mo/^{99m}Tc. Since June 2009, the NEA and its High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) have examined the causes of supply shortages and developed a policy approach, including principles and supporting recommendations to address those causes. The NEA has also reviewed the global ^{99}Mo supply situation periodically, using the most up-to-date data from supply chain participants, to highlight periods of reduced supply and underscore the case for implementing the HLG-MR policy approach in a timely and globally-consistent manner.

In 2012, the NEA released a ^{99}Mo supply and demand forecast up to 2030, identifying periods of low supply relative to demand. This report updates the 2012 forecast[1], focusing on the shorter and potentially critical 2015-2020 period. In that period, one of

[1] The future scenarios presented by the NEA in this report should not be construed as a prediction, forecast or expectation of which projects will proceed and when. The scenarios are only meant to be illustrative of possible future situations, whether planned new projects materialize or not.

the largest irradiators for medical isotopes, the National Research Universal (NRU) reactor in Canada, will cease ^{99}Mo production and the OSIRIS reactor in France will permanently shut down operations. In the same period, new reactor- and non-reactor-based ^{99}Mo/^{99m}Tc projects are expected to be commissioned in various countries. It is important to analyse the overall impact of these supply events to understand how global supply might be affected.

2. Demand Update

In 2011, the NEA released a study with the results of a global survey of future demand for ^{99}Mo/^{99m}Tc (OECD/NEA, 2011), developing a scenario based on a data assessment by an expert advisory group. The study showed ^{99}Mo/^{99m}Tc demand growth up to 2030 in both mature and emerging markets, with stronger growth forecast in emerging markets.

In a subsequent report, *A Supply and Demand Update of the Molybdenum-99 Market (OECD/NEA, 2012)*, the NEA estimated global ^{99}Mo demand at 10,000 6-day curies per week[2]. This was a decrease from the previously estimated 12 000 6-day curies per week, resulting from a number of changes that had occurred in the market as a consequence of the 2009-2010 supply shortage. These changes included: better use of available ^{99}Mo/^{99m}Tc, more efficient elution of ^{99m}Tc generators and patient scheduling, and an increased use of substitute diagnostic tests/isotopes.

As a starting point, the demand scenarios in this report use the NEA 2012 estimate of 10 000 6-day ^{99}Mo curies from processors. However, the NEA has modified the expected demand growth rate from the 2011 study, based on more recent information from supply chain participants. The NEA continues to treat outage reserve capacity (ORC[3]) as an increase in demand for irradiation and processor capacity, as this capacity is required to be 'set-aside' in order to ensure reliability of supply. As a result, a range for demand is presented, including demand plus 35% ORC and demand plus 62% ORC. A third situation, demand with no ORC, is also used for reference in some graphs.

In the HLG-MR principles, it was proposed that a processor should hold sufficient reserve capacity to replace the largest supplier of irradiated targets in their supply chain. This is the (n-1) criterion. In fact, there have been multiple occasions over the last few years when the (n-2) criterion (replacing the two largest suppliers) would have been more appropriate. The 35% level in this paper is based on a calculation of required ORC to maintain supply after the exit of OSIRIS and the NRU from the market, when the largest remaining reactor (the HFR) has an unplanned outage. This reflects the (n-1) criterion for outage reserve capacity post-2016 (a scenario that is likely to happen in the future). The 62% level is based on a calculation of required ORC to maintain supply prior to the exit of OSIRIS and the NRU, when both the NRU

[2] A 6-day curie is the measurement of the remaining radioactivity of ^{99}Mo six days after it leaves the processing facility (i.e. at the end of processing – EOP).

[3] Outage reserve capacity is required to ensure a reliable supply chain by providing back-up irradiation and/or processing capacity that can be called upon in the event of an unexpected or extended shutdown.

and HFR (the two largest irradiators) have unplanned outages. This reflects the (n-2) criterion pre-2016 (a scenario that is unlikely to happen in the future). The “true” required level of ORC is likely between the 35% and 62% levels.

3. Supply scenarios and assumptions

The NEA has updated the list of current and planned new $^{99}Mo/^{99m}Tc$ irradiation and processing projects, based on the most recent information available. The updates include: revisions to production start/end dates, additional potential projects and impacts of converting to using low-enriched uranium (LEU) targets on ^{99}Mo capacity and production. It should be noted that not all planned new production facilities may be operational by the stated times or at all, particularly projects that rely on commercial funding, given the prevailing below-full-cost-recovery prices in the market and the resulting challenges to develop solid business cases. For example, two projects in the United States and one in South Africa have already been suspended due to unfavourable economics.

The supply forecast horizon in this paper is five years (2015-2020) to reflect important changes in global production capacity – the planned cessation of ^{99}Mo production at the NRU reactor in Canada and the OSIRIS reactor in France, and the expected commissioning of new reactor- and non-reactor-based projects in Europe, North and South America, and Australia.

This paper presents a summary of the results from three scenarios for the 2015-2020 period, presented in 6-month intervals (January-June and July-December):

- Reference scenario – a baseline case that includes only current irradiation and processing capacity.
- “Technological challenges” scenario – adds some (but not all) of the planned new ^{99}Mo production capacity. New reactor-based projects, given their proven technology, are assumed to start production on their announced commissioning dates. New alternative (including reactor- and non-reactor-based) projects are assumed to have a 50% probability of starting production on their announced commissioning dates, given their unproven technologies in the market, i.e. only 50% of this new capacity is added in the forecast[4].
- “Project delays” scenario builds on the “technological challenges” scenario by further assuming that LEU conversion and all new projects are delayed by one year – and as a graphic illustration with a two-year delay.

Irradiation capacity in all three scenarios, for each six-month forecast interval, is forecast based on historical reactor operating schedules for the period 2011-2013. In that three-year period, normal available irradiation in each six-month interval has been estimated at approximately 50%, so an even 50/50 split between the two 6-month periods in a year is used in the forecast.

4. It should be noted that new alternative technologies, if proven successful in the market, could be replicated in the future depending on the market conditions (e.g. to satisfy unmet demand) to provide greater supply.

It should be noted that the reference scenario (and by extension, the two alternative scenarios) does not include all announced, new projects[5]. Some projects have been excluded due to the uncertainty of their commissioning within the announced timelines. This is not to suggest that these projects will not become operational, but that they are not likely to in the chosen forecast horizon (2015-2020).

In this paper, the NEA assumes that the impact from LEU conversion on ^{99}Mo production capacity is high given the significant economic and technical challenges to conversion that processors are experiencing, which have led to an extension of their timelines for full conversion.

4. Supply Forecast: Reference Scenario

The reference scenario includes only current ^{99}Mo production capacity – major irradiators and processors that are part of the global supply chain plus Argentina. Although currently not a major producer, Argentina is working towards increasing its production capacity (both irradiation and processing) by the end of the decade to 2 500 six-day Ci/week, which would make it a leading global supplier.

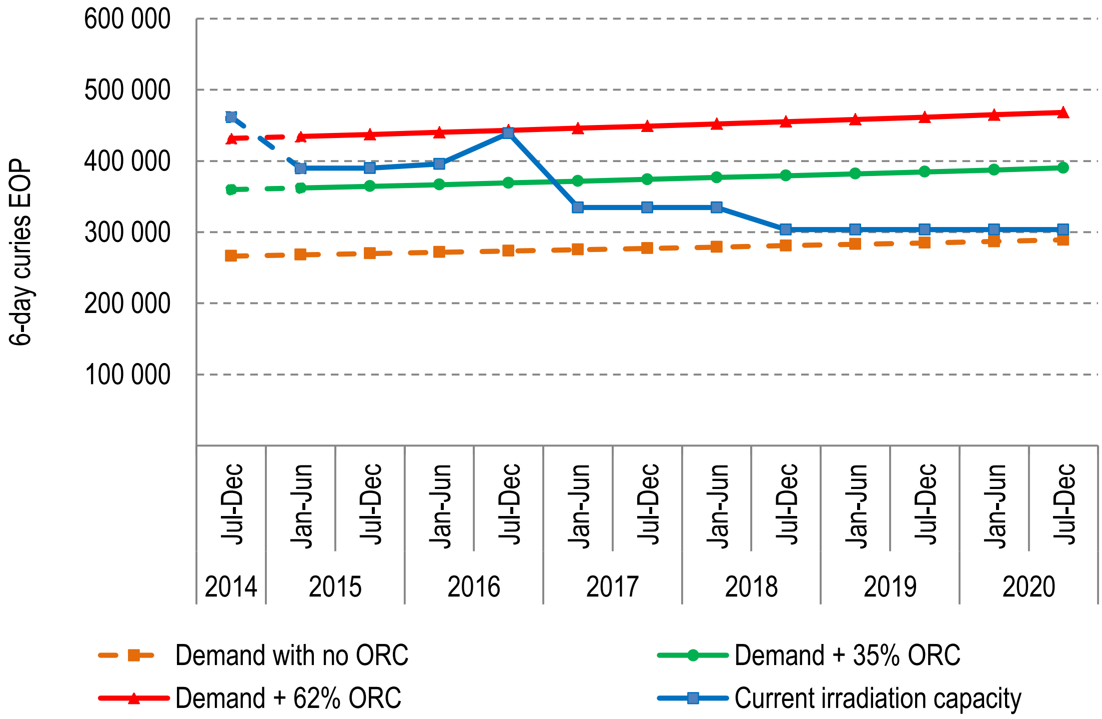
4.1 Irradiation Capacity

As discussed in previous NEA studies, the current fleet of irradiators is ageing and some are expected to stop irradiating targets for ^{99}Mo production within the next few years, while others may experience extended or more frequent periods of maintenance/refurbishment. The planned exit from the global supply chain of the NRU and OSIRIS reactors will significantly decrease the available irradiation capacity, while sufficient new capacity may not be commissioned in time to compensate for this loss. Figure 4.1 below shows the projected 2015-2020 global ^{99}Mo supply and demand based on the capacity of the current fleet of irradiators.

Global available irradiation capacity appears sufficient prior to the BR-2 refurbishment, then it sharply drops, as there is no immediate replacement for the lost BR-2 capacity. The increase in irradiation capacity in the second half of 2016 follows BR-2's return to service. Although this return is planned for the first half of 2016, the increase in global capacity in that period will not be significant, as OSIRIS will be offline too. The drop in capacity in January-June 2017 reflects NRU's exit from the global supply chain. In addition to the permanent loss of capacity from the OSIRIS and the NRU, the full conversion to LEU targets at most of the existing irradiators will further reduce available capacity from the current fleet, although this is not clearly identifiable in Figure 4.1, as the higher capacity of the BR-2 upon its return to service will provide an offset.

Figure 4.1 Current irradiation capacity and demand, 2015-2020

[5] The NEA supply forecast includes only major projects that have a minimum production capacity of 1,000 six-day curies per week EOP. The only exception is the RA-3 reactor in Argentina, which has available capacity of 400 six-day curies per week.



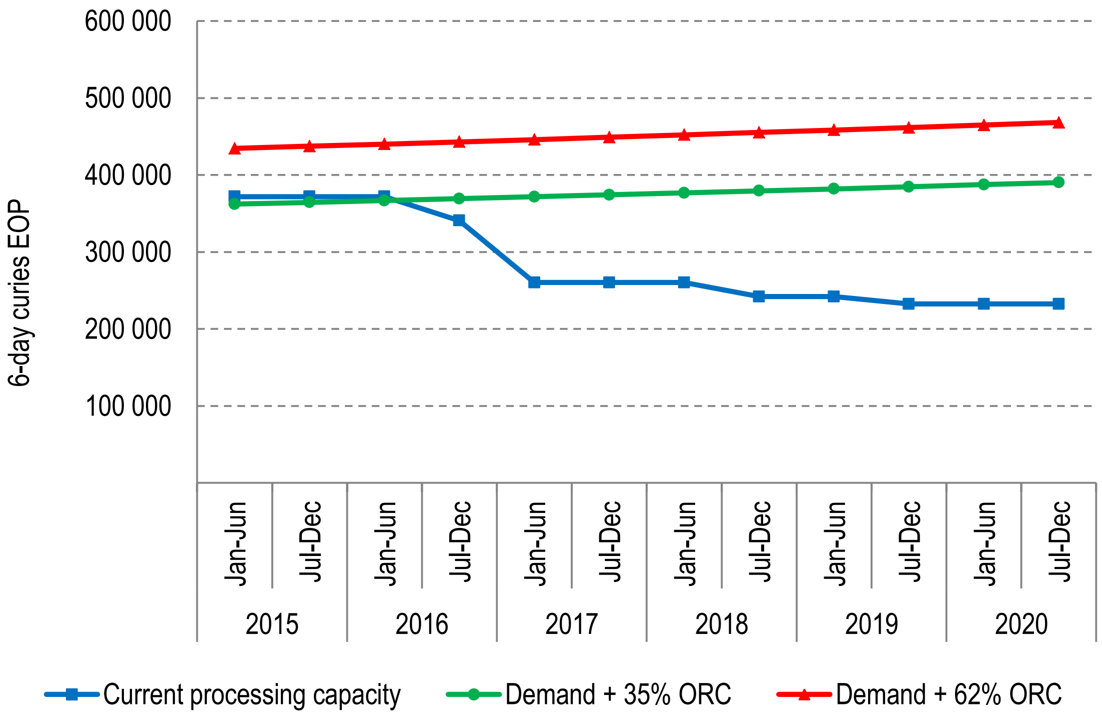
In 2015-2016, irradiation capacity appears to be sufficient to avoid supply shortages; however, as the capacity curve falls below the lower demand curve (i.e. with 35% ORC) post-2016, there is an increased risk of supply interruptions. Figure 4.1 shows clearly that current global irradiation capacity is on a decreasing trend throughout the forecast period. The ageing of major reactors and the consequent higher probability of unplanned or extended outages, along with the impact from LEU conversion, could also impact the processing capacity associated with such reactors and, therefore necessitate investment in new or replacement production capacity. This highlights the need to implement full-cost recovery for ^{99}Mo production to ensure that sufficient irradiation capacity is available in the market.

4.2 Processing Production

Although useful in understanding the global supply situation, irradiation capacity presents only a partial picture and does not account for geographical limitations relating to the production of bulk ^{99}Mo. Not all ^{99}Mo-irradiating reactors have associated processing facilities, which results in regional constraints on processing production and loss of product through higher decay during transportation. This is especially the case in Europe, where irradiation capacity exceeds processing capacity. Therefore, for a more complete analysis of ^{99}Mo supply, it is important to consider processing capacity. Figure 4.2 below shows current processing capacity versus projected demand for ^{99}Mo.

Figure 4.2 shows that global processing capacity is insufficient to ensure secure supply of ^{99}Mo/^{99m}Tc in most of the forecast period. Even at the beginning of the period, when current processing capacity is above the lower demand curve, the gap between capacity and demand is too small to completely avoid any risk to supply. The loss of Canada's processing capacity in the second half of 2016 reduces current global processing capacity by approximately 25% in that period. The planned full conversion to LEU targets is projected to further reduce global processing capacity. Clearly, insufficient processing capacity will be a major risk for secure supply in the next five years.

Figure 4.2 Current processing capacity and demand, 2015-2020



5. 'Project delays' Scenario

This scenario provides, perhaps, the most realistic picture of future irradiation and processing capacity, given the technical complexity of new reactor-based projects and the ground-breaking efforts in reaching large-scale, commercial production by alternative technologies. Furthermore, the majority of the new projects included in this scenario intend to apply full-cost recovery for their future ^{99}Mo production and need to develop distribution networks for their product, which provides an additional challenge to implementation. Most importantly, however, experience has shown that nuclear-related projects more often than not take longer to complete than originally envisaged.

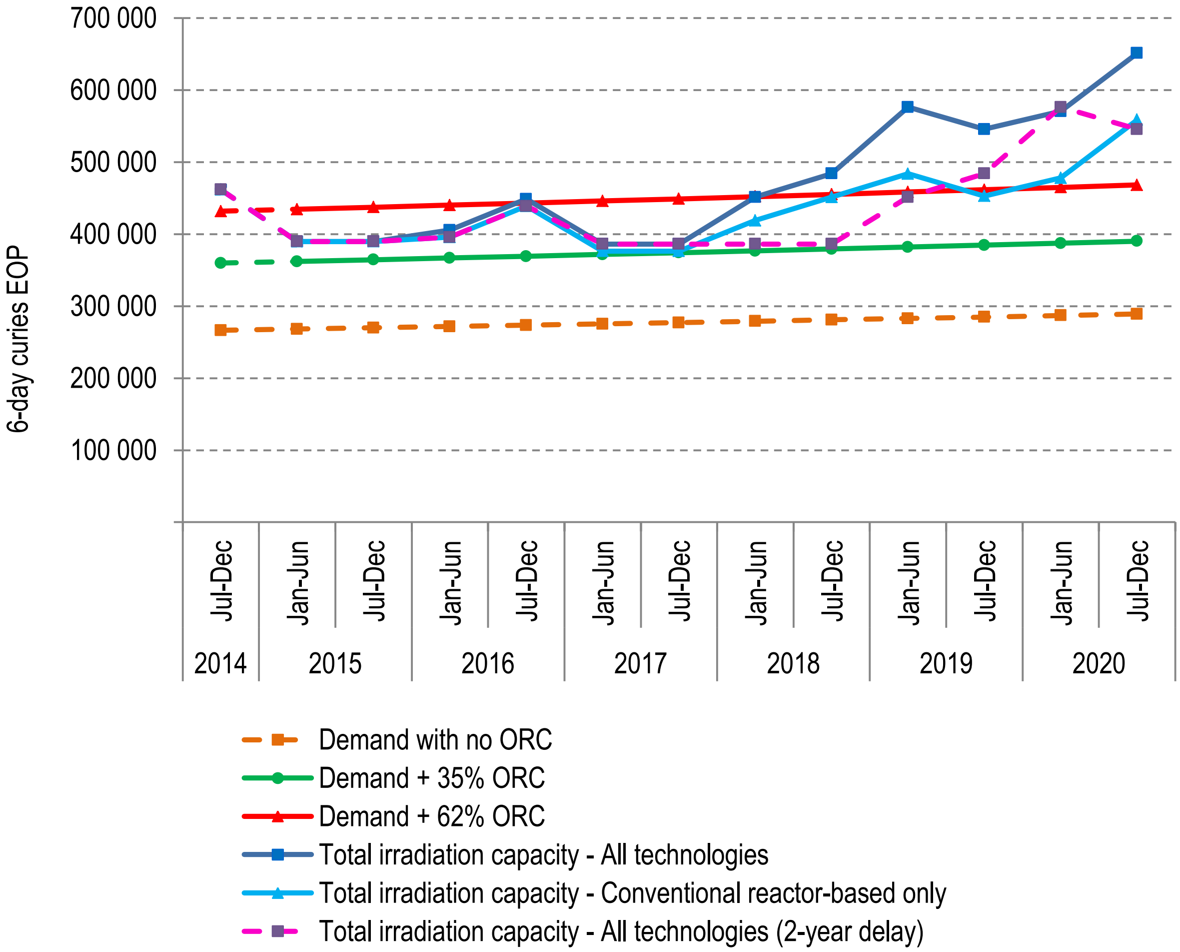
In this scenario, all new projects and full LEU conversion are assumed to be delayed by one year. However, given this somewhat arbitrary assumption, the NEA has also modelled global irradiation and processing capacity with a two-year delay. This provides an additional and more conservative capacity scenario that also acknowledges the potential difficulties in executing new projects or refurbishing existing production facilities. The irradiation and processing capacities with a two-year delay are represented by the purple dotted lines in Figures 5.1 and 5.2, respectively. The capacity lines for the different delay periods show that the risk of supply shortages lasts longer the longer the delay in the commissioning of new projects, as LEU conversion has a less significant impact on overall capacity.

5.1 Irradiation capacity

Figure 5.1 shows the projected global irradiation capacity in the project delays scenario. Global irradiation capacity increases in 2016, as a result of the return to service of the BR-2 reactor, but drops sharply in 2017 due to the one-year delay of the commissioning of major new projects. In this scenario, delayed new capacity will have a negative effect on irradiation capacity, but at the same time, delayed LEU conversion will have the opposite effect. Over the five-year forecast period, the "delayed new capacity" effect will dominate, resulting in lower total irradiation capacity.

Irradiation capacity in Figure 5.1 is split into total capacity and capacity only from reactor-based projects. The gap between the two capacity curves is equal to the amount of alternative capacity. This gap emerges in 2018, when the first alternative production project is expected to utilise its full capacity in this scenario. Supply without these non-reactor projects is tight until 2018.

Figure 5.1 Current and selected new irradiation capacity and demand, 2015-2020

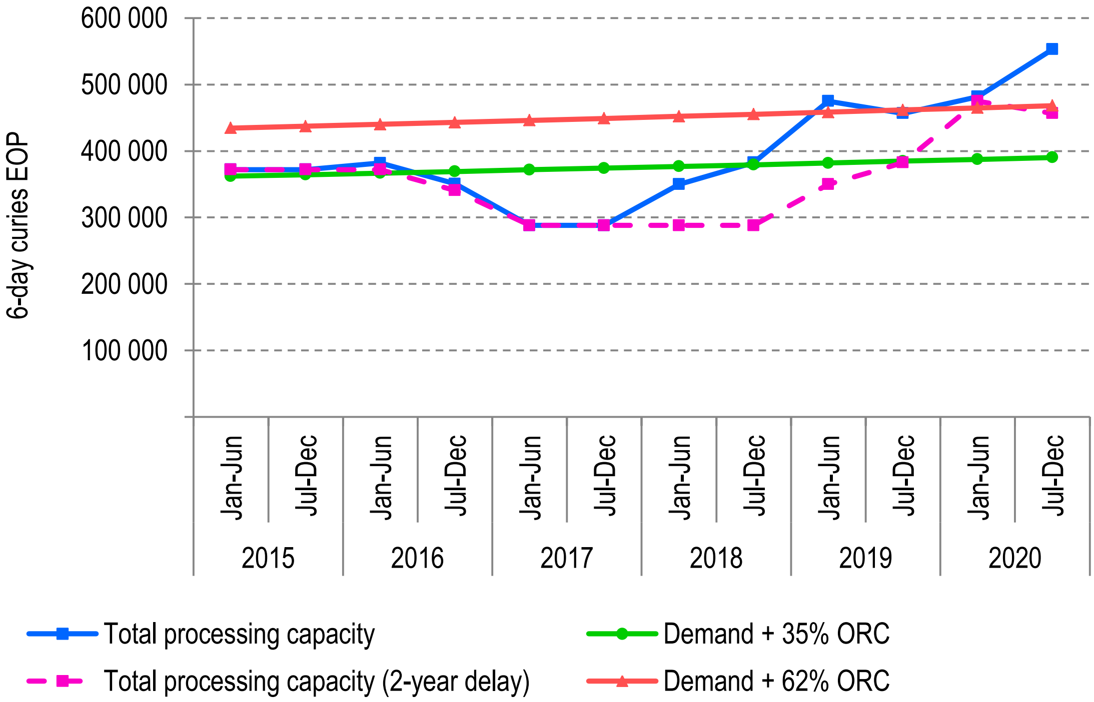


5.2 Processing capacity

From the beginning of the forecast period until mid-2016, global processing capacity is just above the lower demand curve (with 35% ORC) in Figure 5.2 below, suggesting an increased risk of shortages. Processing capacity decreases sharply in 2017 (even higher risk of shortages due to the delay in planned new projects with processing capacity), before increasing in 2018.

The delay of LEU conversion does not have a significant impact on total processing capacity, except for a temporary dip in the second half of 2019, when a large producer is expected to complete its conversion. Figure 5.2 shows that post-2018, processing capacity is projected to reach a level that presents a lower risk of global ^{99}Mo supply shortages.

Figure 5.2 Current and selected new processing capacity and demand, 2015-2020



6. Conclusions

Current global irradiation and processing capacity is predicted to be insufficient over the period analysed for reliable ^{99}Mo/^{99m}Tc supply, even with all producers operating under normal conditions, i.e. without any unplanned or extended outages. As a consequence, there is an increased risk of supply shortages, particularly in the 2015-2017 period, which suggests a need for additional capacity. A closer look at the forecast results in this paper shows that there is a greater need for additional processing capacity to ensure the security of supply.

This ^{99}Mo/^{99m}Tc capacity forecast confirms previous forecasts of tight and potentially insufficient supply in the short term. The planned exit of the OSIRIS and the NRU reactors (and especially, NRU's associated processing capacity) from the global supply chain poses challenges to meet demand. On the other hand, the anticipated commissioning of new capacity as early as 2015 raises hopes that these short-term challenges can be overcome. However, any actual delays in production from that capacity, which are not unlikely given the innovative nature of the production technologies involved, could cause supply difficulties. Furthermore, it is not clear whether these alternative production technologies (which are to be commercially based) will be price competitive in the market, because not all current ^{99}Mo producers, many of whom are subsidised, will have implemented full-cost recovery by then.

The results from this 2015-2020 capacity forecast reinforce the need to establish an economically sustainable ^{99}Mo/^{99m}Tc supply chain as quickly as possible. This would enable investment in new/replacement, non-HEU-based production capacity and its timely entry in operation, and provide sufficient amounts of funded ORC to the market. The ageing fleet of research reactors – the backbone of global ^{99}Mo production at present and for the foreseeable future – and recent extended outages at major producers, underscore the importance of universally adopting full-cost recovery and funded ORC.

References

Available at www.oecd-nea.org/med-radio:

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