Medical Isotope Supply - $^{99}Mo/^{99m}Tc$ Market Demand and Production Capacity Projection: 2016-2021

2016 Mo-99 Topical Meeting

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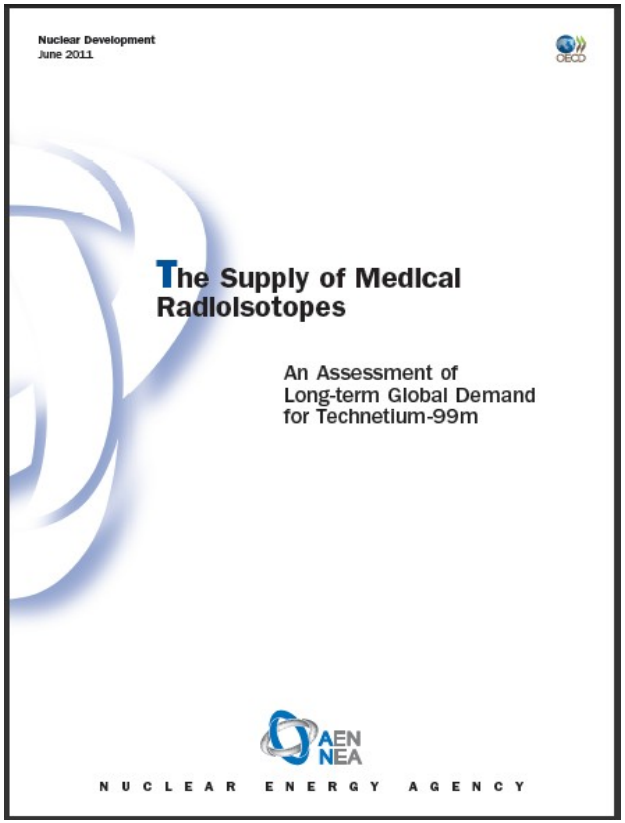
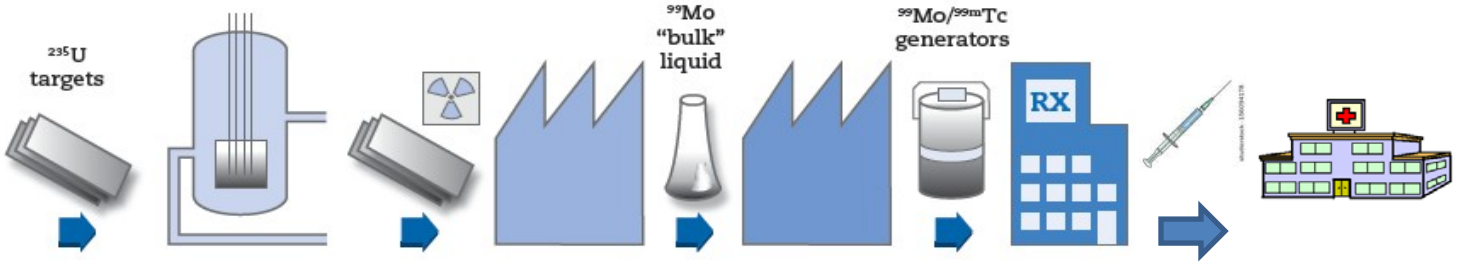
- The Nuclear Energy Agency (NEA) is a specialist agency of the Organisation for Economic Co-operation and Development (OECD), an intergovernmental organisation of 31 industrialised countries based in Paris
- The NEA MISSION - To assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal basis required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purpose

- The High-level Group on the security of supply of Medical Radioisotopes (HLG-MR) was established at the request of NEA member countries, following the 2009-2010 ^{99}Mo supply shortage
- HLG-MR - First Terms of Reference
  - review the total ^{99}Mo supply chain from uranium procurement for targets to patient delivery and identify weak points and issues
  - recommend options to address the vulnerabilities to help ensure stable and secure supply of radioisotopes
  - work with supply chain participants to implement policy recommendations
- HLG-MR is now in its fourth mandate (2015-2017)

- 1st Mandate: June 2009-2011:
  - assessed the factors making the supply chain vulnerable.
  - supply and demand data collected and analysed
- Some Key Findings
  - identified a classical “market failure”.
  - economic structure unsustainable: does not support investment
  - potential shortages as current infrastructure reaches end of life.
- Output
  - developed 6 policy principles





The HLG-MR 6-Principle Policy Approach

- 6 policy principles agreed to by all major ^{99}Mo-producing countries:
  - all ^{99}Mo/^{99m}Tc supply chain participants should implement full-cost recovery (FCR)
  - reserve production capacity (Outage Reserve Capacity - ORC) should be sourced and paid for by the supply chain
  - governments should establish a proper environment for efficient and safe market operations, without intervening directly
  - governments should help facilitate the conversion to low-enriched uranium by reactors and processors
  - international collaboration should continue through a policy and information-sharing forum
  - periodically review the supply chain's progress towards economic sustainability and security of supply

Recent Supply Performance

- The existing supply chain participants have successfully met some difficult challenges in the last few years
  - despite some operational problems, supply has been maintained with only minor disruptions in some countries
    - OSIRIS (F) end of operation December 2015
    - BR-2 (B) 9-month major refurbishment, back in service July 2016
    - HFR (NL) 1 Cycle of unplanned outage in October 2015
- Successfully meeting demand has been achieved by
  - better co-ordination and planning (AIPES R&I Workgroup)
  - supply chain diversification
  - active risk management activities
  - more paid ORC held in the supply chain

2016 Study - Data Collection

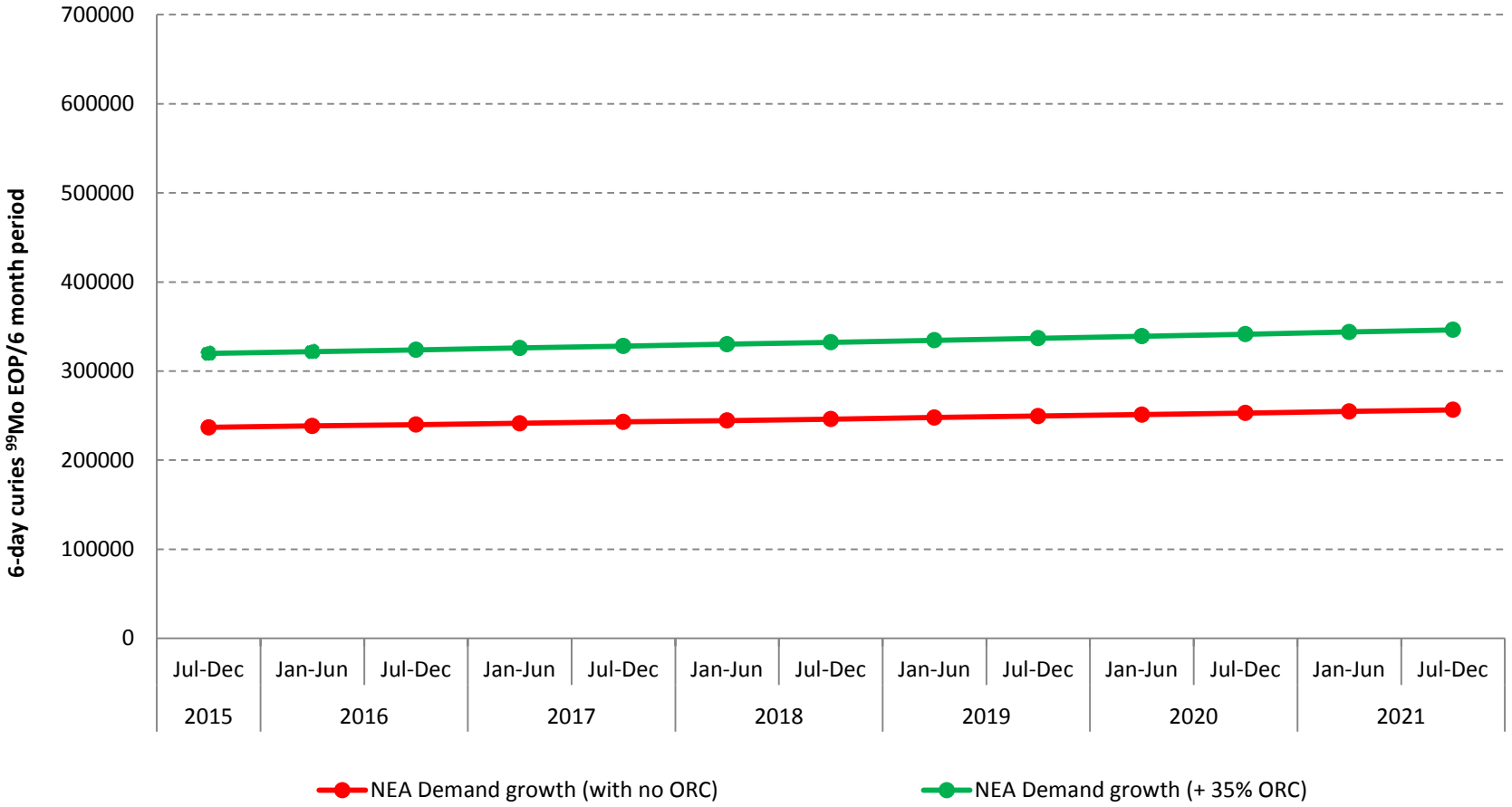
- Data collection process
  - analysis was at the irradiator and processor level
  - retrospective Quarterly % capacity-use data was provided by most market participants for 2012, 2013, 2014 and 2015
  - current irradiator and processor capacity tables were reviewed and corrected by participants, including prospective changes
  - prospective new project timeline plans were collected and reviewed in a single structured format and revised tables developed

Demand 2016-2021

- A revised OECD-NEA Demand and Capacity Projection 2016-2021 has been prepared and published
- Demand level was established by retrospective analysis of reactor and processor capacity usage
  - demand growth rate has been left unchanged from previous reports
- The report identifies the total market demand for the last 4 years was structurally lower than had been previously estimated
  - demand estimate held at 9,000 6-day Ci ^{99}Mo per week EOP

Demand 2016-2021

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC, Demand 2016-2021



Capacity 2016-2021

- Capacity projections 2016-2021 prepared for three scenarios for both irradiation capacity and processing capacity
  - **Reference** scenario A:- existing supply chain only
  - **Technological Challenges** scenario B:- Reference scenario A + qualified new projects and recogising some new technology challenges
  - **Project Delays** scenario C:- Technological Challenges scenario B + delays to new projects (+ 1 year delay)

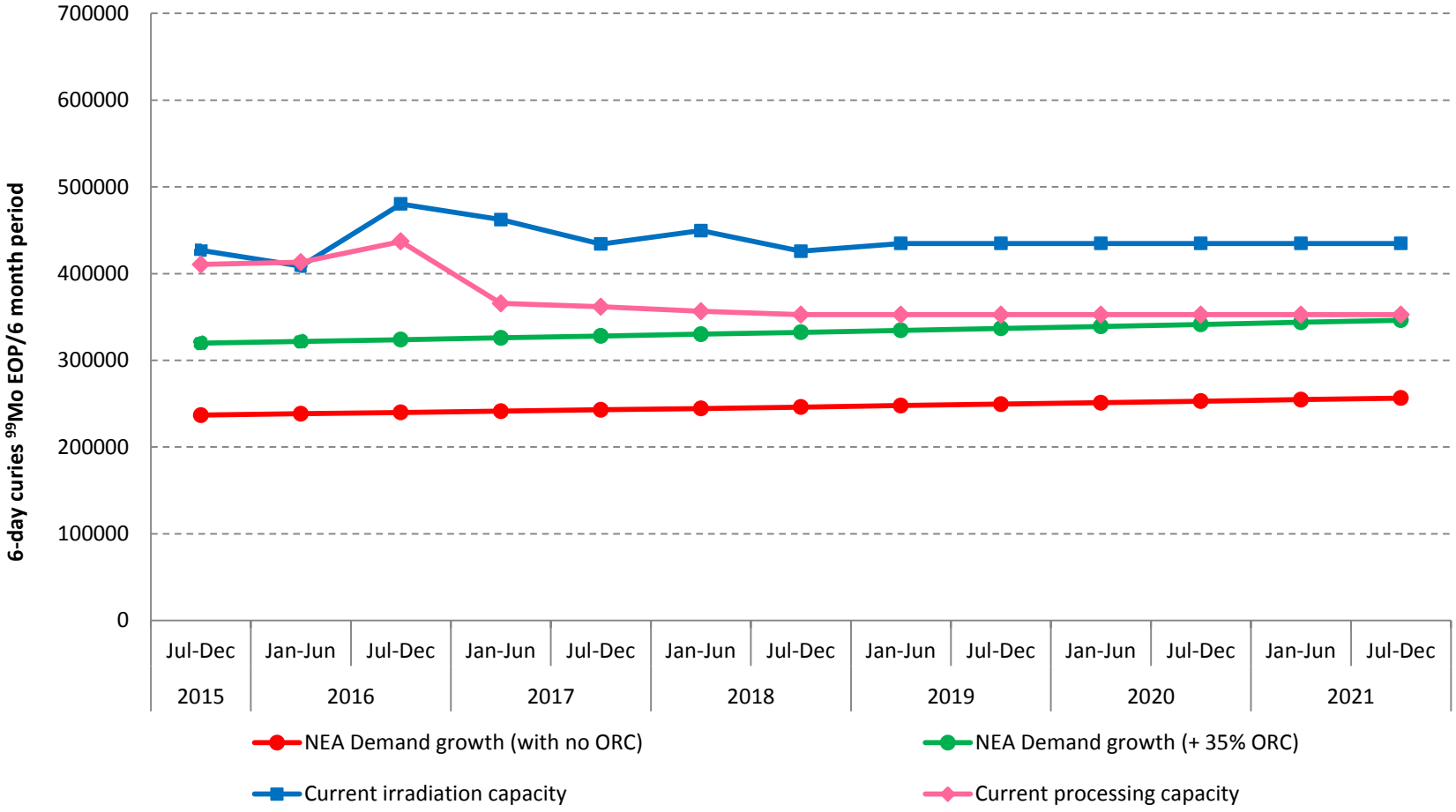
Capacity 2016-2021

- Review of the 2014 and 2015 reports confirmed that project delays continue to occur, particularly to new technologies and large scale projects
  - this confirms that it is well justified to model scenarios with some project timeline slippage

- The assumed LEU conversion effects (-10% capacity effect) are unchanged from the 2015 report

Capacity 2016-2021 - Scenario A

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC vs. Current Irradiation and Processing Capacity - Reference Scenario A

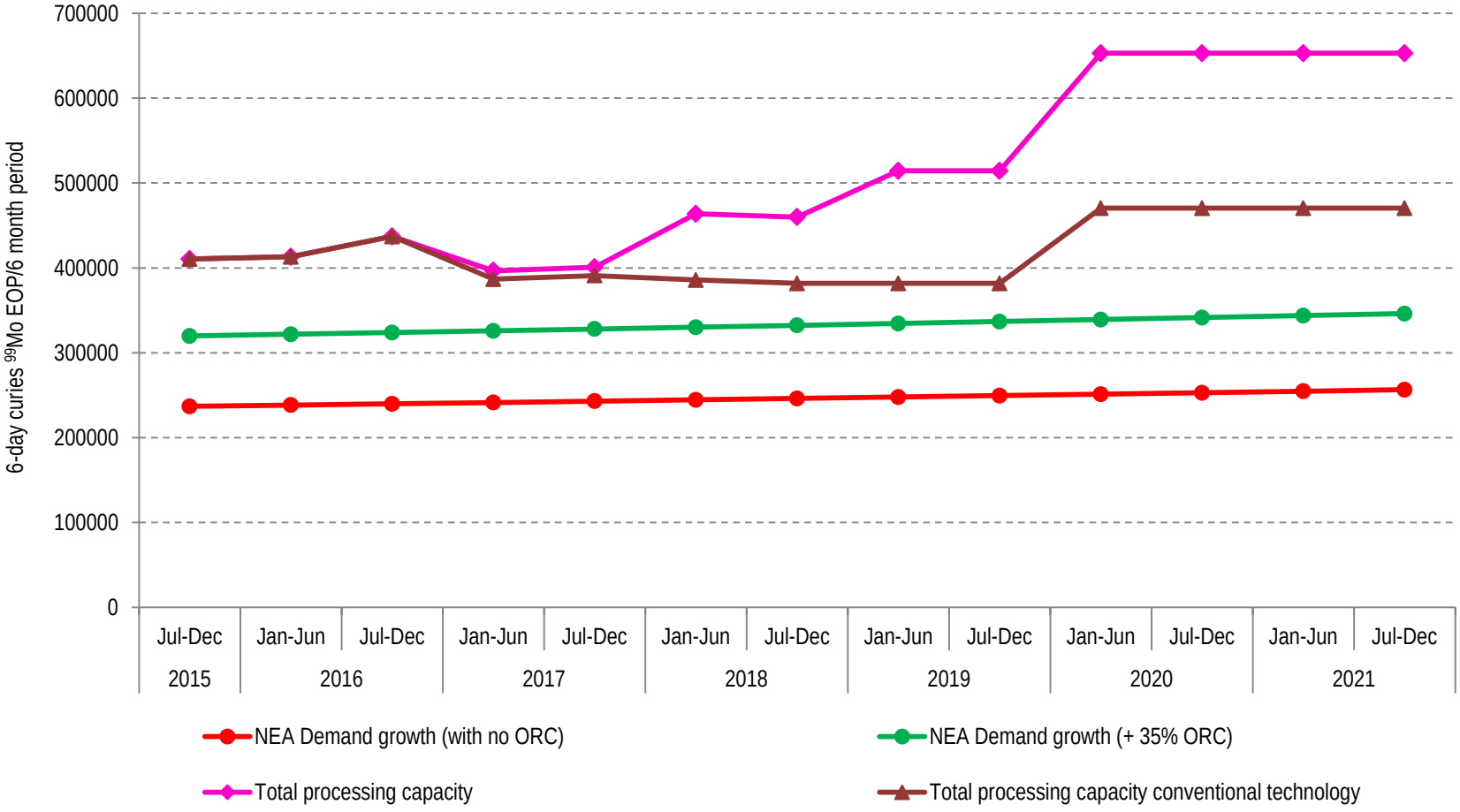


Capacity 2016-2021 - Scenario A

- Reference scenario A - Conclusions
  - in the reference scenario, the additional capacity introduced in the existing facilities has moved the long term processing capacity higher
    - now remains above the NEA demand +35% ORC line to 2021
  - the existing supply chain, if well maintained, planned and scheduled, will be able to manage limited unplanned outages throughout the projection period
    - the capability to manage adverse events will reduce slowly

Processing Capacity 2016-2021 – Scenario B

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC vs. processing capacity "total" and "conventional only" - Scenario B

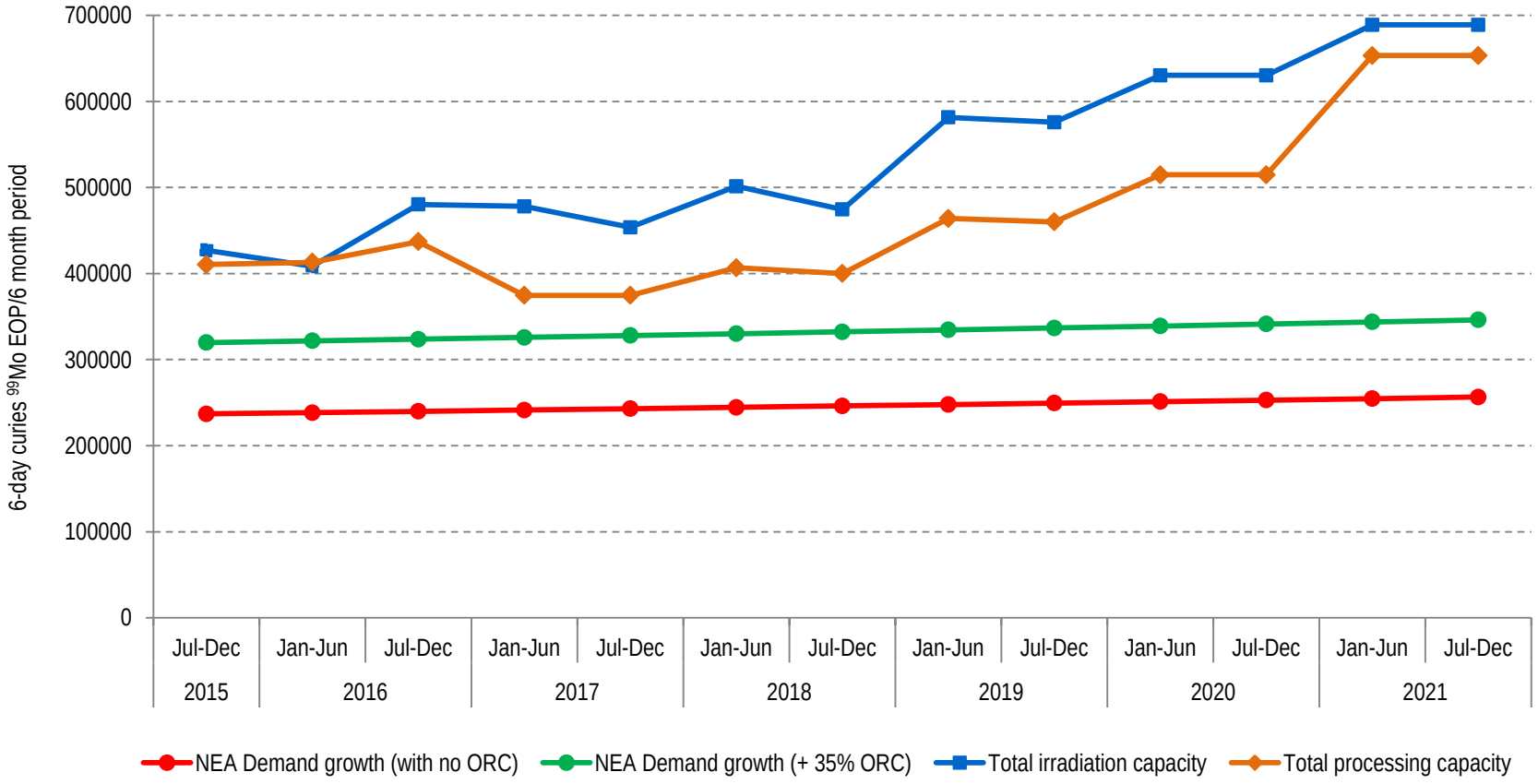


Processing Capacity 2016-2021 – Scenario B

- Technological Challenges scenario B - Conclusions
  - additional processing capacity in the technological challenges scenario B now starts in 2017, so later than in the 2015 report
    - additive value of alternative technologies has not occurred yet, due to some project delays
    - additive processing capacity that comes primarily from projects in the United States and Canada now begins in 2017
  - from 2018 capacity addition is projected to be progressive and quite substantial until 2020
    - indicating that the capacity addition from alternative technology can increase the overall security of supply
    - however, some alternative technology processing capacity is linked one-to-one with alternative technology irradiation capacity; this increases the level of challenge in those projects

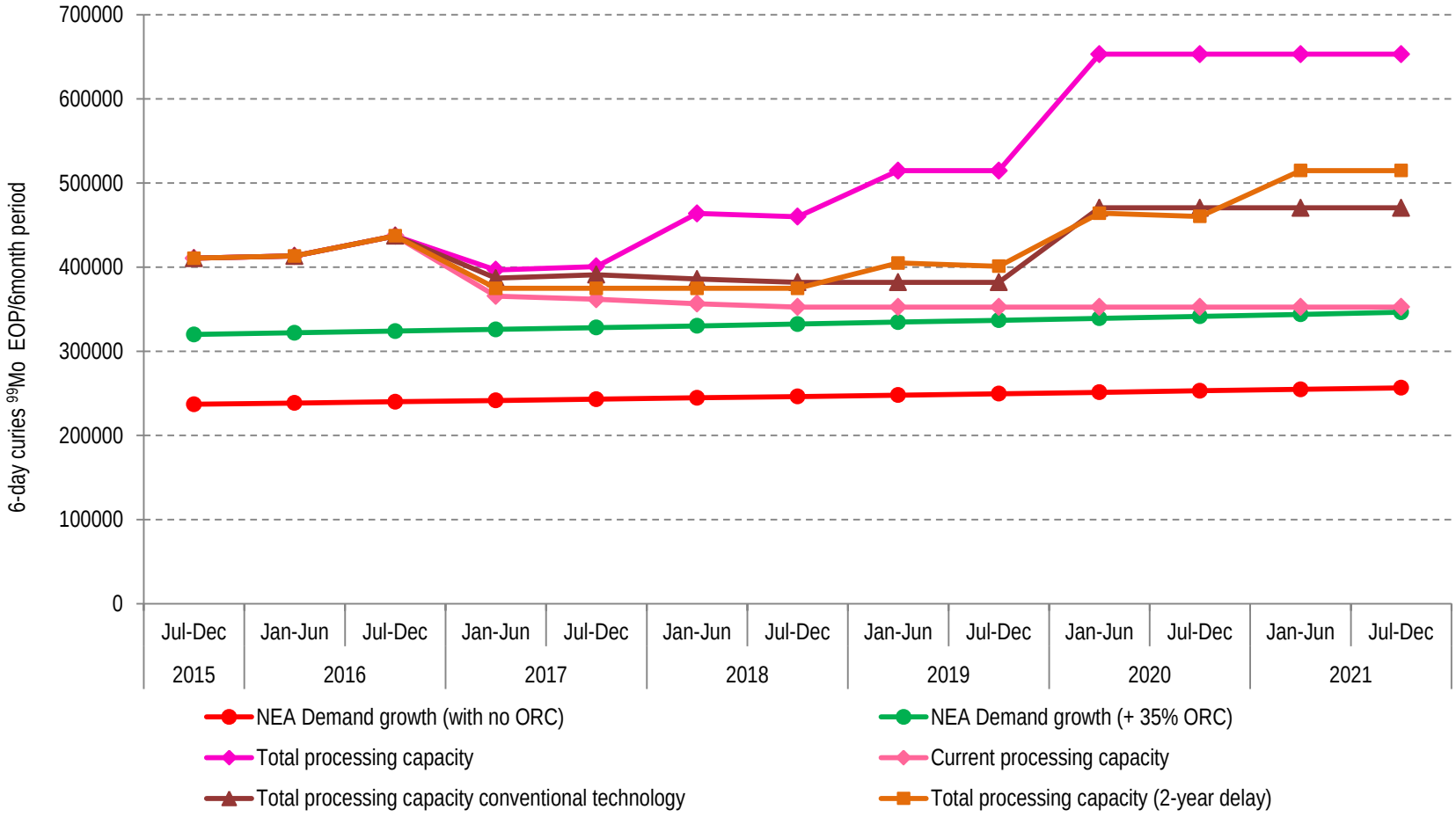
Capacity 2016-2021 – Scenario C

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC v total irradiation capacity and total processing capacity – projects delayed: Scenario C



Processing Capacity 2016-2021- Further Challenges

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC vs. processing capacity – current, total, total conventional only and total 2-year delay



Processing Capacity 2016-2021 – Scenario C

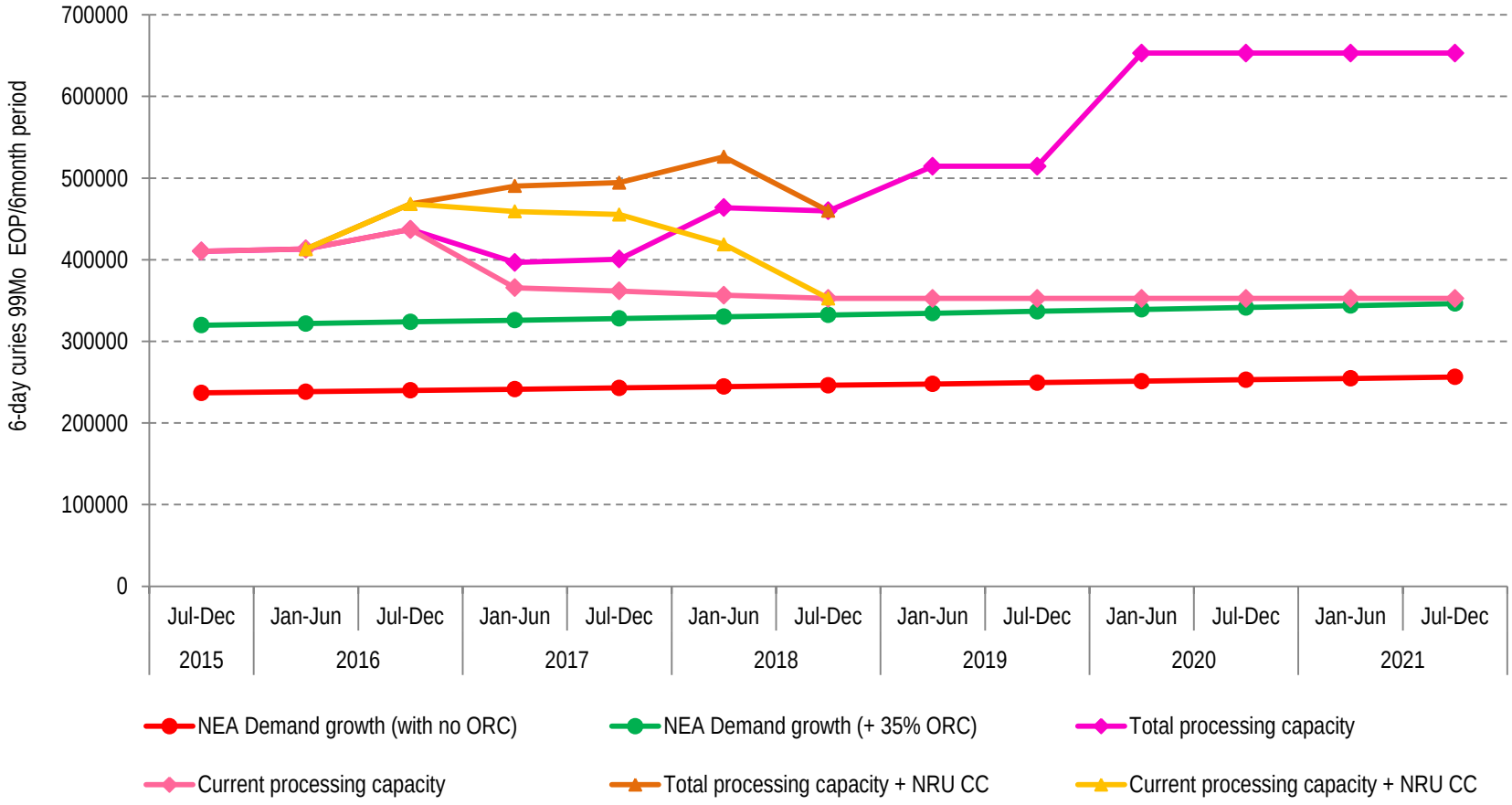
- Project Delays Scenario - Conclusions
  - the most important effect of project delays is that the total processing capacity line is lower
    - closer to the NEA demand +35% ORC line in 2017
    - indicates a lower level of reserve capacity
    - underlines the importance of the on-time introduction of new conventional processing capacity in Australia, which is reported as remaining on schedule
  - the intermediate projections confirm that overall processing capacity reduces when projects are significantly delayed
    - as a result total processing capacity could remain close to the reference scenario levels until 2020

NRU Contingency Capacity 2016-2021

- Potential NRU Contingency Capacity
  - the operating licence for the NRU reactor has been approved from 1 November 2016 to 31 March 2018 for non-^{99}Mo purposes, keeping the NRU reactor in “hot operation”
    - associated facilities required for ^{99}Mo processing will be kept in a “hot standby” mode for the same period
  - NRU Contingency Capacity (NRU CC) will only be made available under special conditions of market supply shortage
    - unexpected circumstance of significant shortages
    - only if alternative technologies or other sources of supply are not available to meet demand
  - Protocols are in place to manage NRU CC if needed

NRU Contingency Capacity 2016-2021

Current demand (9 000 6-day Ci ^{99}Mo/week EOP) and demand +35% ORC v processing capacity – current and total, with and without NRU CC



NRU Contingency Capacity 2016-2021

- Potential NRU Contingency Capacity - Conclusions
  - the extension of the NRU operating period could be a useful stop-gap in the 2017 and early 2018 period
  - however, in the event that slow progress is made with alternative technologies, or when all processing projects are substantially delayed, then the projected processing capacity can still return to the Reference scenario level in 2018, with the associated concerns about the level of reserve capacity

Key Points

- Demand estimate maintained at 9 000 6-day ^{99}Mo Ci/wk EOP
- There is a need to add processing capacity by 2017
  - on-time introduction of substantial conventional processing capacity in Australia is important
  - as is the introduction of alternative irradiation and processing technologies
- If these are achieved, capacity should be fully secured for the period to 2021, however supply will continue to require careful and well considered planning to minimise risks
- Regular monitoring and periodic review will be needed, particularly the progress in bringing new capacity to market
- Supply is secure, economic sustainability remains a challenge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