The most profitable non-energy application of nuclear technology in industry is arguably nuclear medicine (diagnostics and treatment), particularly the production and use of [radioisotopes](https://www.google.com/search?cs=1&sca_esv=53af40c892478f71&sxsrf=AE3TifMuIhQj4cak-cnuBiodlBbscgVXYA:1753869178393&q=radioisotopes&sa=X&ved=2ahUKEwil4cnqp-SOAxXLHRAIHZgdPZcQxccNegQIAhAC&mstk=AUtExfDBieIhPYih7lPQju5lSExxCmfVMKwsvK3s6e5jrlbBDTwD0F92caTHoiYzv85yp1HC3BEVdXZjBfMvE0bqrYtxLhVdPtxH86SleY8xbScG5d3nnW1I_Pl0SJVN07I3pddOKwTLAbL4y4HnPHWlpXi9vwpn2LokzjMPvtidabB0WZDUC3wuQQI4LqrNYxII4sEvsdKcRKVP-RGaSnuKGovQLtxa8HlBe-EvrRpLYRSiM7PTOAMyZsUjiE7GV_PA6tvGs-pNjphTbFCiz05YeOki&csui=3" \t "https://www.google.com/_blank) like [technetium-99m (Tc-99m)](https://www.google.com/search?cs=1&sca_esv=53af40c892478f71&sxsrf=AE3TifMuIhQj4cak-cnuBiodlBbscgVXYA:1753869178393&q=technetium-99m+(Tc-99m)&sa=X&ved=2ahUKEwil4cnqp-SOAxXLHRAIHZgdPZcQxccNegQIAhAD&mstk=AUtExfDBieIhPYih7lPQju5lSExxCmfVMKwsvK3s6e5jrlbBDTwD0F92caTHoiYzv85yp1HC3BEVdXZjBfMvE0bqrYtxLhVdPtxH86SleY8xbScG5d3nnW1I_Pl0SJVN07I3pddOKwTLAbL4y4HnPHWlpXi9vwpn2LokzjMPvtidabB0WZDUC3wuQQI4LqrNYxII4sEvsdKcRKVP-RGaSnuKGovQLtxa8HlBe-EvrRpLYRSiM7PTOAMyZsUjiE7GV_PA6tvGs-pNjphTbFCiz05YeOki&csui=3" \t "https://www.google.com/_blank).

**Q1**:What is the most profitable non-energy application of nuclear technology in industry? Particularly?

This is due to the high demand and commercial value of radioisotopes *for medical imaging and therapies*. Tc-99m is crucial for diagnostic imaging, allowing doctors to visualize organs and identify diseases. Radioisotopes are also used in targeted cancer therapies, such as brachytherapy for prostate cancer. 99mTc is used in tens of millions of medical diagnostic procedures annually.

**Q2**: For what do we use  [technetium-99m (Tc-99m)](https://www.google.com/search?cs=1&sca_esv=53af40c892478f71&sxsrf=AE3TifMuIhQj4cak-cnuBiodlBbscgVXYA:1753869178393&q=technetium-99m+(Tc-99m)&sa=X&ved=2ahUKEwil4cnqp-SOAxXLHRAIHZgdPZcQxccNegQIAhAD&mstk=AUtExfDBieIhPYih7lPQju5lSExxCmfVMKwsvK3s6e5jrlbBDTwD0F92caTHoiYzv85yp1HC3BEVdXZjBfMvE0bqrYtxLhVdPtxH86SleY8xbScG5d3nnW1I_Pl0SJVN07I3pddOKwTLAbL4y4HnPHWlpXi9vwpn2LokzjMPvtidabB0WZDUC3wuQQI4LqrNYxII4sEvsdKcRKVP-RGaSnuKGovQLtxa8HlBe-EvrRpLYRSiM7PTOAMyZsUjiE7GV_PA6tvGs-pNjphTbFCiz05YeOki&csui=3" \t "https://www.google.com/_blank)?

**HISTORY**: In 1938, [Emilio Segrè](https://en.wikipedia.org/wiki/Emilio_Segr%C3%A8" \o "Emilio Segrè) and [Glenn T. Seaborg](https://en.wikipedia.org/wiki/Glenn_T._Seaborg" \o "Glenn T. Seaborg) isolated for the first time the [metastable isotope](https://en.wikipedia.org/wiki/Metastable_isotope" \o "Metastable isotope) technetium-99m, after bombarding natural molybdenum with 8 MeV [deuterons](https://en.wikipedia.org/wiki/Deuteron" \o "Deuteron) in the 37-inch (940 mm) [cyclotron](https://en.wikipedia.org/wiki/Cyclotron" \o "Cyclotron) of [Ernest Orlando Lawrence](https://en.wikipedia.org/wiki/Ernest_Orlando_Lawrence" \o "Ernest Orlando Lawrence)'s [Radiation laboratory](https://en.wikipedia.org/wiki/Lawrence_Berkeley_National_Laboratory" \o "Lawrence Berkeley National Laboratory).

**Q3**: Who did discover isotope technetium-99m?

The production and medical use of 99mTc rapidly expanded across the world in the 1960s, benefiting from the development and continuous *improvements of the [gamma cameras](https://en.wikipedia.org/wiki/Gamma_camera" \o "Gamma camera)*.

**Q4**: When did the expansion use of 99mTc take place?

Production and distribution of 99mTc generators were transferred to private companies. "TechneKow-CS generator", the first commercial 99mTc generator, was produced by Nuclear Consultants, Inc. (St. Louis, Missouri) and [Union Carbide](https://en.wikipedia.org/wiki/Union_Carbide" \o "Union Carbide) Nuclear Corporation (Tuxedo, New York).[[19]](https://en.wikipedia.org/wiki/Technetium-99m" \l "cite_note-19)[[20]](https://en.wikipedia.org/wiki/Technetium-99m" \l "cite_note-20) From 1967 to 1984, 99Mo was produced for [Mallinckrodt Nuclear Company](https://en.wikipedia.org/wiki/Mallinckrodt_Incorporated" \o "Mallinckrodt Incorporated) at the [Missouri University Research Reactor](https://en.wikipedia.org/wiki/University_of_Missouri_Research_Reactor_Center" \o "University of Missouri Research Reactor Center) (MURR).

**LITERATURE**:

1. Eckelman WC, Coursey BM, eds. (1982). Technetium - 99m : generators, chemistry and preparation of radiopharmaceuticals. Oxford: Pergamon.

1. Nuclear Consultants Inc (December 1966). ["Injectable sodium pertechnetate 99mTc from your own compact production facilities"](http://radiology.rsna.org/content/87/6/local/front-matter.pdf) (PDF). Radiology. 87 (6): 36A. [doi](https://en.wikipedia.org/wiki/Doi_(identifier)" \o "Doi (identifier)):[10.1148/87.6.1128](https://doi.org/10.1148/87.6.1128)

**ECONOMICS ISSUES**: The global nuclear medicine market is experiencing substantial growth, projected to reach $36.9 billion by 2027, [according to MDPI](https://www.mdpi.com/1996-1073/18/4/858). Economical issues associated with nuclear medicine market *are under the influence of different government policies*. For example: “Recent unilateral withdrawal of USA from Iran nuclear deal (Joint Comprehensive Plan Of Action-JCPOA) followed by imposing economic, trade and financial sanctions against Iran, has deleterious effect on nuclear medicine either on supply of radiotracers or spare parts of nuclear medicine devices. Although medicine is apparently not included in the list of sanctions, secondary sanction, aviation and transport embargo as well as financial restrictions, made it extremely difficult for medical companies to be able to do any transaction. Payment for the drugs or instruments and shipment of the goods to and from Iran have turned to a lengthy, difficult and risky task. Nuclear medicine seems to be at particular risk due to its link with atomic energy agency. […] It has shown that the negative effect of sanctions has ranged from death to different complications of disease mainly due to limited access to the drugs”, how *National Library of Medicine*[[1]](#footnote-0) provided us in 2019.

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Using isotopes in non-energy medical applications—such as diagnostics (e.g., imaging) and therapy (e.g., cancer treatment)—has many benefits but also presents significant economic issues. Here’s a breakdown of the key economic challenges:

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1. High Production and Procurement Costs

• Specialized Facilities: Medical isotopes like Technetium-99m or Iodine-131 require nuclear reactors or cyclotrons for production. Building and maintaining these facilities is capital-intensive.

• Short Half-Lives: Many isotopes decay quickly (e.g., Tc-99m has a 6-hour half-life), so they must be produced frequently and used promptly, increasing operational costs.

• Import Dependence: Many countries lack isotope production facilities and must import isotopes, making them vulnerable to international supply disruptions and currency exchange fluctuations.

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2. Supply Chain and Distribution Challenges

• Cold Chain Logistics: Isotopes often require strict storage and transportation conditions to maintain their integrity, which raises costs.

• Regulatory Hurdles: Stringent regulations for transporting radioactive materials add to bureaucratic and financial burdens.

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3. Cost of Equipment and Infrastructure

• Imaging Devices: Equipment like PET/CT and SPECT scanners are very expensive to acquire and maintain.

• Shielding and Safety: Facilities must be designed with radiation shielding, monitoring systems, and disposal procedures, which involve high up-front and ongoing costs.

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4. Skilled Workforce Requirements

• Training and Salaries: Specialists in nuclear medicine, radiopharmacists, and radiation safety officers are required. Training them and maintaining staff increases operational expenses.

• Limited Availability: A shortage of qualified personnel in some regions drives up labor costs and limits service expansion.

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5. Inequitable Access and Affordability

• High Patient Costs: The end-user (patients) often faces high prices for diagnostic or therapeutic procedures using isotopes, especially in countries without public healthcare or insurance coverage.

• Urban Concentration: Services are usually concentrated in urban centers, limiting access for rural or underserved populations.

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6. Research and Development Costs

• Innovation Expenses: Developing new isotopes or improving production and imaging techniques requires substantial R&D investment.

• Long ROI Periods: Returns on such investments can be slow due to complex approval processes and limited market sizes.

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7. Waste Disposal and Environmental Costs

• Radioactive Waste Management: Disposing of spent isotopes safely is costly and highly regulated.

• Environmental Impact: Cleanup and containment of accidental releases (though rare) can incur huge economic liabilities.

1. https://pmc.ncbi.nlm.nih.gov/articles/PMC6352058/ [↑](#footnote-ref-0)