

ARTICLE

Ailing reactors and their isotopes: radiopharmacy and nuclear research in Belgium (1990–2020)

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Abstract

This article studies the relation between research reactors, the development of nuclear research centres and the pharmaceutical industry in the recent history of nuclear medicine. While existing scholarship has rightfully highlighted how medical applications served as a useful argument to de-militarize the image of large-scale nuclear research infrastructure during the Cold War, this study extends this perspective beyond the Cold War era. Using the Belgian Nuclear Research Centre as a case study, this article highlights how their orientation was negotiated within economic and political considerations. From the 1990s onwards, therapeutic radiopharmaceuticals experienced increasing attention, while the amount of radioisotope-producing reactors was decreasing. In an era that had become more critical of nuclear infrastructure, this article shows how the production of radioisotopes became a social-political argument in the preservation of test reactors.

Keywords: Big Science; nuclear history; radiopharmaceuticals; Euratom; radioisotopes; Belgium

Introduction

In 2022, the *Emergency Response Team* (ERT) from the industry association *Nuclear Medicine Europe* reported two major disruptions in the supply of radioisotopes, the raw elements that are used for radiopharmaceutical examinations and treatments in hospitals. In the case of molybdenum-99, they were facing ‘a massive shortage’ while it also affected the supply of Lutetium-177 and Iodine-131 isotopes.¹ Molybdenum-99, the source of technetium-99m, is widely used in hospitals for diagnostic purposes, whereas other radioisotopes (Lu-177, I-131) are used, respectively, for prostate and thyroid cancer. The cause of the shortage, however, lay far outside the hospitals, namely at test reactors located at nuclear research centres that were founded in the 1950s. The High Flux Reactor (HFR) in Petten (the Netherlands) suffered from an ‘unplanned outage’, while the Belgian Reactor 2 (BR-2) in Mol (Belgium) had a ‘mechanical failure’.² As these events indicate, contemporary practices in nuclear medicine, in particular radiopharmacy, are sometimes intimately linked to nuclear research infrastructure from the early Atomic Age.

¹Curium, ‘Re: Updated Information on Upcoming Mo99 Shortage Affecting the TEK CIS Generator’, 28 October 2022. Available at: <https://www.bnms.org.uk/page/SupplyUpdatesFromIndustry> (Accessed 13 August 2024).

²NMEu Emergency Response Team (ERT), ‘Subject: Unplanned Outage of the HFR Reactor’, 24 January 2022; NMEu to EU Observatory for the Supply of Medical Radioisotopes, ‘Global Mo-99 and I-131 Production Impacted by Delay of Two Reactors Restarting from Scheduled Maintenance’, 20 October 2022. Available at: <https://www.bnms.org.uk/page/SupplyUpdatesFromIndustry> (Accessed 13 August 2024).

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The relationship of influence and dependency between test reactors and medical markets was, however, not a one-way affair. The origins of most European test reactors lie in the Atoms for Peace programme, which provided financial support to sell American reactors abroad.³ Recipient countries, including the Netherlands and Belgium, constructed test and research reactors primarily to facilitate national nuclear energy programmes, with the production of radioisotopes merely as a by-product. By 2016, however, the hierarchy of priorities had flipped, and a 40-million-euro refurbishment to give the Belgian reactor ‘a second life’ was justified by designating the reactor’s main purpose as to ‘fight cancer’.⁴ This brief anecdote illustrates that test reactors not only came to play a key role in the supply chain of contemporary nuclear medicine but also, in reverse, that medical applications increasingly became an attractive political, societal, and financial justification for nuclear research centres to sustain their most prominent research infrastructure. The revived attention to this infrastructure is also reflected in the European Commission’s initiative to establish a ‘European Radioisotope Valley’ in order to ‘maintain Europe’s global leadership’ in the supply of medical radioisotopes.⁵

The complex relation between nuclear infrastructure and medical applications is well established in the historiography of science, technology, and medicine. Historicising radioisotopes has proven to be a fruitful way to connect the material artefacts in the history of science and technology with the broader political, industrial, and economic contexts of modern medicine in the early Cold War. For example, radioisotopes played an important role in de-militarising the image of early nuclear research, a role that Angela Creager described as ‘atomic humanitarianism’.⁶ Similarly, Alison Kraft has shown how the ‘rise of the radioisotope’ in the United Kingdom was viewed as ‘politically expedient’ by the government because it, in part, legitimised the vast public investments in nuclear infrastructure.⁷ Néstor Herran extended this analysis from the domain of research to that of industrial applications, highlighting how Cold War research funding indirectly subsidised the industrial use of radioisotopes.⁸ From a diplomatic point of view, the spread of radioisotopes and exchange programmes in the early atomic era were also politically useful, as they made the United States appear as a country willing to share its nuclear knowledge, without giving away its information on weapons or reactors.⁹ This illustrates that from the very beginning, medical aspects of nuclear research played a role in its justification, a view well established in current academic literature.

Much less understood is how and why test reactors and medicine became rhetorically aligned between 1990 and 2020 in ways that show resemblances with the early atomic age, despite the stark differences in the historical context. Much historiography on science policy has identified the 1970s and 1980s as a turning point with an increasing emphasis on market forces and economic impact of state-funded research as its marker.¹⁰ Moreover, the 1970s and 1980s are often understood as a time in which nuclear technology received increasingly critical responses, while other fields such as biotechnology and material

³Mara Drogan, ‘The Nuclear Imperative: Atoms for Peace and the Development of U.S. Policy on Exporting Nuclear Power, 1953–1955’, *Diplomatic History*, 40, 5 (2016), 964–70.

⁴Saar Sinnaeve, ‘Kernreactor in Mol krijgt tweede leven om kanker te bestrijden,’ *De Tijd*, 28 October 2016. <https://www.tijd.be/politiek-economie/belgie/algemeen/kernreactor-in-mol-krijgt-tweede-leven-om-kanker-te-bestrijden/9825564.html> (Consulted: 4 February 2026). Translation by author.

⁵‘SAMIRA Action Plan’, https://energy.ec.europa.eu/topics/nuclear-energy/radiological-and-nuclear-technology-health/samira-action-plan_en (Consulted 22 November 2025).

⁶Angela N.H. Creager, *Life Atomic: A History of Radioisotopes in Science and Medicine* (Chicago: University of Chicago Press, 2015), 5–9; 406.

⁷Alison Kraft, ‘Between Medicine and Industry: Medical Physics and the Rise of the Radioisotope 1945–65’, *Contemporary British History*, 20, 1 (2006), 2.

⁸Néstor Herran, ‘The “Bounties of Our New Servant”: Isotopes, Industry, and Economy Before and After Atoms for Peace’, *Journal of Cold War Studies*, 25, 3 (2023), 14–34.

⁹Jacob Darwin Hamblin, *The Wretched Atom: America’s Global Gamble with Peaceful Nuclear Technology* (Oxford University Press, 2021), 18.

¹⁰Philip Mirowski, *Science-Mart. Privatizing American Science* (Cambridge, MA: Harvard University Press, 2011); Elizabeth Popp Berman, *Creating the Market University. How Academic Science Became an Economic Engine* (Princeton, NJ: Princeton University Press, 2012).

sciences captured the attention of politicians. While originally associated with large-scale government-funded programmes in particle accelerators, space rockets, and reactors, several historians have highlighted that many national laboratories (in Europe and the U.S.A.) shifted away from their original orientation and not seldomly embraced biomedical fields as a new justification for their activities and instruments.¹¹ One explanation for this evolution is that biomedicine and material science perhaps aligned more easily with the values of entrepreneurship and measurable utility that reflected a post-Cold War moral economy.¹²

This article challenges current historiography by putting a test reactor (and those who managed it) at the heart of analysis, shifting the analytical focus from science policy to the actors who managed and justified their instrument through shifting political priorities. Test reactors, as historian Mark Bowles has rightly pointed out, have rarely attracted the attention of historians in their own right, playing at best a secondary role in histories of either atomic energy or atomic weapons, overlooking the alternative histories that those instruments offer.¹³ Using the Belgian BR-2 reactor as a case study is particularly instructive, given the country's remarkable absence in nuclear historiography. Not only does Belgium today belong to the major players in the global radioisotope market, but it has also been an international frontrunner in public funding for nuclear research and development (R&D) since the 1960s. By 2013, Belgium's public spending on nuclear R&D was (slightly) higher than that of France, when calculated as a percentage of the gross domestic product.¹⁴ To explore this history, this article is based on extensive archival research at the Belgian Nuclear Research Centre (SCK CEN), and it uses the Belgian case to provide a lens into the changing international dynamics of radio pharmaceuticals between 1980 and 2020.¹⁵

The thesis developed in this article is that the increasing importance of medical applications in nuclear research centres was not simply a response to changing science policy regimes in the 1980s, but a development that should be understood as a product of accommodation and interdependence between two distinct policy regimes, namely the early Cold War era and the post-1980 era. Throughout this period, the role of test reactors was not purely determined by economic, political, or technological developments, but was actively discussed and managed. This article divides this process into three phases. The first section sketches the various forms of politics that test reactors were involved in from their establishment onwards. In this context, the BR-2 occurs as a national, regional, and institutional object, situated in the politics of Atoms for Peace, Euratom, and Belgian regional politics. Radioisotopes, the second section shows, became a possible but also contested form of justification for test reactors when large publicly funded research programmes declined in the 1980s. While understood as more politically acceptable than nuclear energy, this was a financially insufficient argument to maintain test reactors. The third phase, starting in the 1990s, reflects increasingly optimistic views on therapeutic rather than diagnostic applications. Throughout these phases, new strategic orientations always inherited the consequences of early Cold War science policy in which governments had provided vast investments that slowly decreased from the 1980s onwards.

Radioisotopes have often been called 'tracers' in biomedicine, but equally function for historians as tracers for complex historical interactions and developments in nuclear science and technology. Next to physicians and patients, radiopharmacy also involves research reactors, processing facilities, pharmaceutical companies, and (university) hospitals. This article shows how the Belgian research reactor's position was actively managed in this supply chain that was connected through radioisotopes.¹⁶

¹¹Robert Crease and Catherine Westfall, 'The New Big Science', *Physics Today* (2016), 30–36; Olof Hallonsten, *Big Science Transformed: Science, Politics and Organization in Europe and the United States* (Palgrave Macmillan, 2016), 81.

¹²Robert Crease and Catherine Westfall, 'The New Big Science', *Physics Today* (2016), 34.

¹³Mark D. Bowles, *Science in Flux: NASA's Nuclear Program at Plum Brook Station, 1955–2005* (Washington, DC: Government Printing Office, 2006), xxiv–xxv.

¹⁴OECD/IEA, *Energy Policies of IEA Countries: Belgium 2016* (Paris: OECD/IEA, 2016), 152, figure 11.2.

¹⁵The archives of SCK CEN are not publicly accessible, and they contain documents in Dutch, French, and English. All quotes used in this article have therefore been translated into English by the author.

¹⁶Inspired by Angela Creager, *Life Atomic* (Chicago, IL: Chicago University Press, 2013), 1–23.

The politics of test reactors

The current importance of the Dutch and Belgian reactors in the international supply chain of radio-pharmacy is relatively new. Since the 1980s, a relatively modest and consolidated market was increasingly concentrated in a few companies, mainly the Canadian Nordion, which supplied the vast majority of molybdenum-99, the source of the most widely used radioisotope (Tc-99m).¹⁷ From the early 2000s onwards, especially, the Netherlands and Belgium became ‘major players in the radioisotope market’.¹⁸ This shift is visible in the production of the aforementioned molybdenum-99. In 2019, the Nuclear Energy Agency from the OECD estimated that the Belgian and Dutch reactors together reflected 41% of the global production capacity of molybdenum, while Canada was no longer listed among the reactor producers, and reactors in South Africa and Australia now reflected 28% of the world production.¹⁹ Between the 1980s and 2020s, there was a shifting geography of radioisotope production. Clearly, the Low Countries became important players on the international market between 2005 and 2020.

The increasingly important role on the global radioisotope market went hand in hand with a more medical orientation of the nuclear laboratories that hosted research reactors. For example, the Dutch Nuclear Research and Consultancy Group (NRG), which exploited the Euratom-owned High Flux Reactor (HFR) reactor in Petten, promoted itself in the 1990s as ‘Medical Valley’.²⁰ The Dutch reactor had primarily been presented as the European radioisotope producer since then.²¹

The current medical orientation of the test reactors in the Low Countries sharply contrasts their Cold War origins. Under the influence of the American Atoms for Peace programme, European countries experienced a wave of small research reactors, followed in the late 1950s by more advanced designs called Material Testing Reactors (MTR).²² Both the Dutch and Belgian reactors were part of this programme, but with an important difference. While the HFR was modelled on the Oak Ridge Research Reactor, the Belgian reactor was a unique reactor designed by the Nuclear Development Corporation of America (NDA), in cooperation with Belgian engineers (see Fig. 1). The director of the Belgian Nuclear Research Centre (SCK CEN), Louis de Heem, had publicly announced in 1956 that Belgium aimed for ‘the most advanced test reactor in continental Europe’.²³ This decision came with financial consequences. The total construction costs of the BR-2 were estimated at 20 million dollars, more than four times those of the runner-up from Sweden (R2).²⁴ In order to share the burden of the annual operating costs, BR-2 was considered feasible only in cooperation with the Euratom programme.

Although established in the context of Atoms for Peace, the early fate of the European reactors was determined by internal Euratom politics. European ambitions for the BR-2 were quickly undermined after the newly elected French president, Charles de Gaulle, pursued a nationalistic rather than European

¹⁷National Academies of Sciences, *Engineering, and Medicine*, Molybdenum-99 for Medical Imaging (Washington: The National Academies Press, 2016), 26; Néstor Herran and Sebastian Grevsmühl, *The First Nuclear Industry: Radioisotopes, State and Society* (Research Report, 2017), 50–51.

¹⁸Néstor Herran and Sebastian Grevsmühl, *The First Nuclear Industry: Radioisotopes, State and Society* (Research Report, 2017), 2.

¹⁹OECD/NEA, *The Supply of Medical Isotopes: An Economic Diagnosis and Possible Solutions* (Paris: NEA/OECD, 2019), 85, table 4.2.

²⁰A. Keverling Buisman and J. Heijn, ‘Medical Valley. Nuclear Medicine in the Dunes of Petten, Netherlands; Medical Valley. Nucleaire geneeskunde in de Pettense duinen’ (December 1996). See <https://www.osti.gov/etdweb/biblio/398939> (Consulted: 6 February 2026).

²¹Edgar Koonen, ‘Overview of the Material Testing Reactors in the World’, in Hamid Ait Abderrahim (ed.), *Research Facilities for the Future of Nuclear Energy – Proceedings of an ENS Class 1 Topical Meeting* (Singapore: World Scientific Publishing, 1996), 6.

²²Mark D. Bowles, ‘Nuclear Research and Test Reactors’, in Joseph Martin and Cyrus Mody (eds.), *Between Making and Knowing* (Singapore: World Scientific, 2019), 377–89.

²³Louis De Heem, ‘Mise au point ...’, *Bulletin d’information – Association belge pour le développement pacifique de l’énergie atomique* (1956), 11.

²⁴Anonymous, ‘Belgium’s BR-2 Critical’, *Nucleonics*, 19, 8 (1961), 29; United States Congress Joint Committee on Atomic Energy, *Review of the International Atomic Policies and Programs of the United States, Report to the Joint Committee on Atomic Energy Congress of the United States*, Vol. 1, (Washington, DC: United States Government Printing Office, 1960), 6, table 1.1.

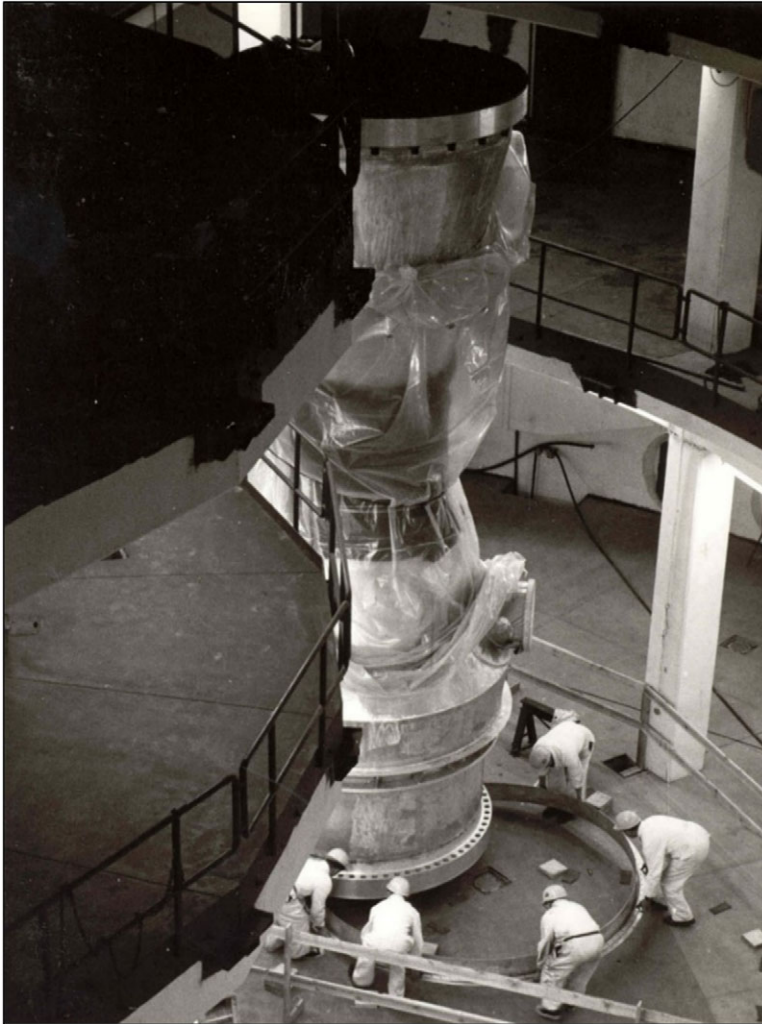


Figure 1. Installation of BR2's reactor vessel in 1960. Courtesy of SCK CEN.

approach to nuclear matters.²⁵ One of the consequences of this approach was the establishment of another MTR near Paris, called Osiris. While the simultaneous construction of two reactors in the Low Countries was already met with questions regarding potential overcapacity and inefficient use of financial resources, the French reactor undermined both the Dutch and Belgian reactors.²⁶ An American analyst concluded in 1967 that the establishment of material testing reactors in Europe was yet another example of 'noncoordination' within the European nuclear programme, characteristic of the multinational project that was undermined by national protectionism.²⁷ Bilateral projects on breeder reactors kept the test reactors afloat throughout the 1970s and 1980s.²⁸

²⁵Mervyn O'Driscoll, 'The Origins and Early History of Euratom, 1955–1968', in Gordon Lake (ed.) *The European Parliament and the Euratom Treaty: Past, Present and Future* (Luxembourg: European Parliament, 2002), 31–32.

²⁶Ed. 'Onnodig geld in kernonderzoek? Nog meer samenwerking in de Benelux bepleit', *Limburgs Dagblad*, 18 October 1961.

²⁷Lawrence Scheinman, 'Euratom: Nuclear Integration in Europe', *International Conciliation*, vol. 36, no. 563 (1967), 55, footnote 94.

²⁸Otto Keck, *Policymaking in a Nuclear Program: The Case of the West German Fast Breeder Reactor* (Lexington: Lexington Books, 1981), 243.

Although discussions regarding costs and finances were never alien to test reactors – the head of the Belgian Atomic Energy Commission considered the BR-2 ‘too big and too expensive’ already in 1965 – these discussions became more pressing in the 1980s.²⁹ While government funds for collaborative Fast Reactor research had long provided work for all European reactors, those test reactors became competitors as soon as programmes and projects became scarce. Test reactors embedded in international networks such as Euratom (HFR, Netherlands) and the OECD (HBWR, Norway), or with a large domestic research market (Osiris, France), were more favourably positioned in this competitive environment, while those in Belgium and the UK came under financial scrutiny (see Fig. 2). What worked against the BR-2 in particular was that, during the 1970s and 1980s, it had mostly facilitated external projects, and its associated departments therefore rarely developed expertise in initiating projects themselves, giving the reactor, later on, the nickname ‘neutron cow’, being primarily a service provider.³⁰

The changing international research opportunities shifted the narratives surrounding the BR-2 throughout the 1980s from being seen as an international flagship instrument to a financial burden. In 1961, the directors of the reactor presented it as a ‘European’ reactor, a narrative that continued until the 1980s.³¹ However, in 1986, government-hired auditors quickly pointed out the financial impact of the BR-2 research reactor, suggesting a complete shutdown.³² Although scientists and engineers involved managed to dissuade the minister from such actions, the Belgian government did stipulate in 1991 that no more than one third of SCK CEN’s subsidies could be spent on the BR-2, implying that at least 50% of the reactor’s costs should be covered by external income.³³ A study from the University of Leuven in 1991 indicated that there was an increasing pressure to run the reactor in a more industrial and financially responsible way, namely as a ‘profit centre’.³⁴ Although this evolution towards financial accountability shows similarities with other case studies, often conceptualised as a form of neoliberalism, it is noteworthy that the BR-2’s treatment was gentler than some others. The British research reactors at Harwell, DIDO and PLUTO, were fully shut down in March 1990.³⁵ The survival of the BR-2 shows the limits of neoliberalism as an encompassing explanatory framework for science in the 1980s.

The framework of neoliberalism also does not explain the increasing importance of radioisotopes in the Belgian nuclear sector. The importance of radioisotopes primarily became of political interest in the context of internal Belgian communitarian conflicts. Throughout the 1980s, Belgium increasingly federalised providing more responsibilities to three regions (Flanders, Wallonia, and Brussels). Similar to international counterparts, the Belgian Nuclear Research Centre was supposed to develop expertise in non-nuclear domains, but those domains were now seen as of Flemish economic interest and therefore ‘heavily criticised by the francophones’.³⁶ Conversely, francophones were more defensive on nuclear matters, particularly the BR-2. ‘Francophones are strongly committed to the continuation of the BR2’, a report from 1987 noted, ‘because, among other reasons, the [Institute for Radio Elements, I.R.E.] is

²⁹Jacques Errera to Roger Neyrinck, ‘*Memorandum sur le secteur nucléaire*’, 5 August 1965. Algemeen Rijksarchief 2 – Archives générales du Royaume 2 – Dépôt Joseph Cuvelier – I 007 – 5602.

³⁰Luc van den Durpel, Potential Role for SCK CEN in Scientific and Technological Irradiation Services, Draft Report for Discussion. 17 June 2002. SCK CEN Archive BR2, C, 2, 1.

³¹Georges Denègre, Georges Stiennon, and Fernand Léonard, ‘The European BR2 Reactor at Mol, Belgium’, *New Scientists*, vol. 9, no. 229 (1961), 877–9; J. M. Bagniet et al., *The BR2 Multipurpose Research Reactor: A Tradition of International Collaboration, in Particular for the Development of Fast Breeder Reactors* (Vienna: IAEA, 1988).

³²Hein Brookhuis, ‘Transforming Big Science in Belgium: Management Consultants and the Reorganization of the Belgian Nuclear Research Centre (SCK CEN), 1980–1990’, *Centaurus*, 64, 2 (2022), 498–9.

³³Anonymous, ‘*Refurbishment van BR2. Conclusies & Aanbevelingen*’, 23 November 1994. SCK CEN Central Archive, Box 18, C, 6, 7.

³⁴Bart Nevens and Luc Vints, ‘Optimalisatieproject BR2: kostenanalyse en kostprijsberekening’ (unpublished thesis: KU Leuven, 1991), 9.

³⁵Tom Smith and Ken Nicholson, ‘End of the Line for Harwell’s Dido and Pluto Research Reactors’, *ATOM* 402 (1990), 14–18.

³⁶‘Kerngegevens SCK’, 16 September 1987, KADOC, Jef Vanwildemeersch Archive, Box BE/942855/706/73/1.

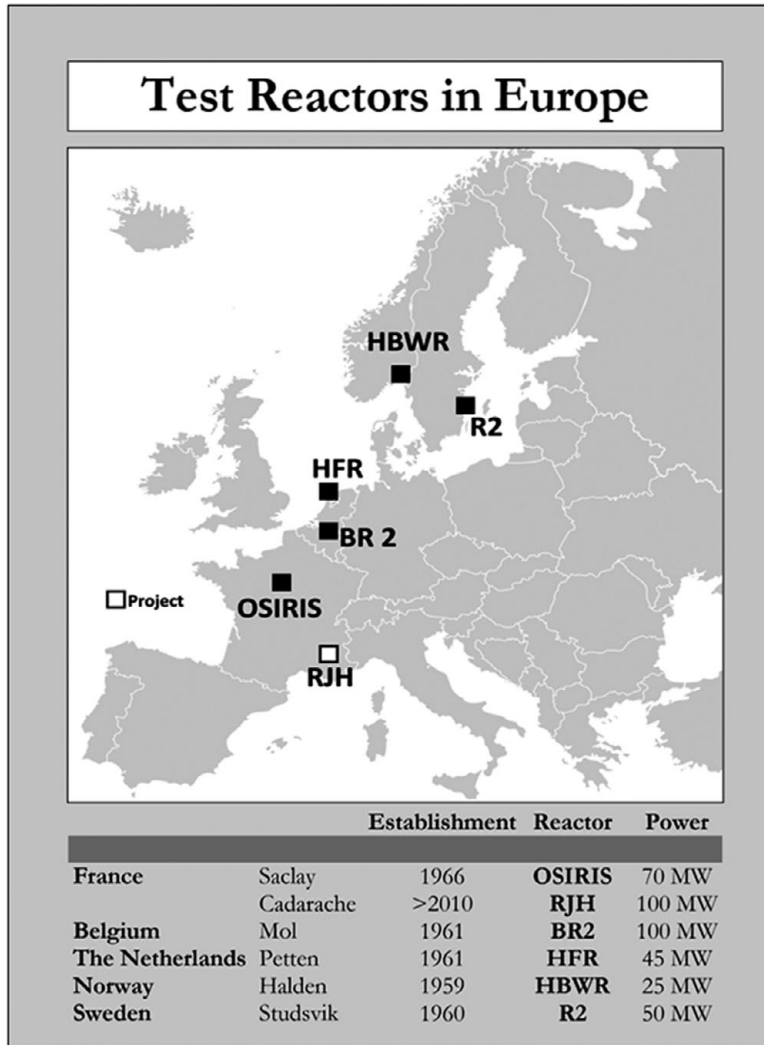


Figure 2. Overview of European test reactors in 2000. Based on Alain Alberman, 'Panorama des réacteurs expérimentaux dans le monde,' RGN 6 (2000), 69.

indirectly subsidized' by this reactor, as it produced cheap radioisotopes for that organisation.³⁷ Although formally split and divided over the two Belgian regions, the radioisotope production formed a *trait d'union* between the nuclear organisations in Belgium, which was a main driving force behind the BR-2's survival.

In Belgium and elsewhere, the production of radioisotopes was conducted separately from the more commercial processing and distribution activities.³⁸ In 1971, this department at SCK CEN was transferred to Walloon territory in Belgium, established as the Institute for Radio-Elements (I.R.E.) in Fleurus.

³⁷'Franstaligen hechten groot belang aan continuïteit van de BR2, omdat ondermeer het IRE indirect gesubsidieerd wordt (isotopenbestralingen voor IRE kosten +/- 120 mln F en brengen slechts 40 à 50 mln F op)'. In: Anonymous, 'Kerngegevens SCK', 16 September 1987, KADOC Archive (Leuven), Jef Vanwildemeersch Archive, Box BE/942855/706/73/1.

³⁸Kraft, *op. cit.* (note 7), 1–35; Angela Creager, 'The Industrialization of Radioisotopes by the U.S. Atomic Energy Commission', in K. Grandin, N. Wormbs, S. Widmalm (eds.), *The Science-Industry Nexus – History, Policy, Implications* (USA, Sagamore Beach, MA.: Science History Publication, 2004), 153–7.

Although this went hand in hand with the growing political tension between the Flemish and Franco-phone communities, it was to a certain extent in line with international trends. Tensions had also existed between the Harwell and Amersham-based radioisotope departments of the UKAEA in the 1950s, and the commercialisation of Amersham was proudly presented in the 1980s as one of the first privatisations of a formerly British state-funded scientific institute.³⁹ The Dutch processing organisation originated within the electronics giant Philips in the south of the country but was quickly relocated to the west, next to the High Flux Reactor at the Dutch nuclear research centre in Petten.⁴⁰ The Belgian separation of responsibilities in the radioisotope industry was thus not unique, although it was interpreted along political communitarian lines more strongly than elsewhere.⁴¹

Despite the political importance of the BR-2 and despite potential future perspectives, the board of SCK CEN still considered the production of radioisotopes as of 'subordinate importance' in 1990.⁴² Towards the end of the 1990s, this perspective had not changed dramatically. Operational costs of the BR-2 were estimated at around 500 million francs, while the maximum income would be around 80 million francs, covering less than 20% of the total reactor costs. The institute's marketing manager, Jef Vanwildemeersch, concluded that 'none of the production perspectives provide a sufficient argument for the preservation of the reactor'.⁴³ Research reactors, Vanwildemeersch believed, were 'ailing', especially in an environment that provided neither 'an economic nor scientific justification' for the preservation of the reactors.⁴⁴ Even the production of radioisotopes was not considered a sufficient justification to maintain the reactor.

The sceptical view on radioisotopes as a justification for a test reactor also informed SCK CEN's position when France, Belgium, and the Netherlands considered replacing their ageing test reactors by the turn of the century.⁴⁵ The reactor manager of the BR-2, Pol Gubel, overseeing both research and production activities, did not consider radioisotopes as a legitimate argument for such large-scale investments. In Gubel's view, test reactors should be constructed for a wide variety of purposes, both experimental and production, but not solely for medical applications. The fact that their European partners disagreed was 'probably Petten's lobby' from the Dutch institute, he believed.⁴⁶ Within Belgium, Gubel's view contradicted that of the I.R.E. In fact, the I.R.E.'s director, Henri Bonet, had argued in front of the Belgian Nuclear Society in February 2005 that the 'appropriateness' of the design of some of the future research reactors 'can be challenged' when it came to their usefulness for nuclear medicine.⁴⁷ This was particularly problematic for SCK CEN. Since the 1990s, they had also been working on a new test reactor, a so-called Accelerator-Driven System (ADS), but the management was made aware that the I.R.E.'s director had explicitly argued that those systems 'are not feasible for [molybdenum-99] production'.⁴⁸ He considered the new reactors unnecessarily ambitious, arguing that 'the political world should

³⁹Kraft, *op. cit.* (note 7), 18–24; Jon Agar, *Science Policy Under Thatcher* (London: UCL Press, 2019), 170–87.

⁴⁰Marja Hoeke and Peter Vermeeren, 'Beknopte geschiedenis van de productie van radiofarmaca in Nederland', *Tijdschrift voor Nucleaire Geneeskunde*, 40, 4 (2018), 2097–8. This organisation is nowadays known as Curium.

⁴¹Geert Vanpaemel, *Towards a Sustainable Future: The Nuclear Research Centre in Mol (1952–2022)* (Leuven: Acco, 2022), 130–1.

⁴²Niettegenstaande deze perspectieven, blijft de produktie van isotopen in BR2 van ondergeschikt belang aan een optimaal gebruik voor veiligheidsexperimenten, materiaalbestralingen en gericht onderzoek'. In: Meeting report *Raad van Bestuur* 156, 21 February 1990. SCK CEN Archives, Brussels. Translation in text by author.

⁴³Geen enkel productievooruitzicht geef een voldoende argumentatie voor het behoud van de reactor'. In: 'Mail from Jef Vanwildemeersch to Paul Govaerts, SCK – NRG', 5 February 1999, SCK CEN Central Archive. Box 3, B, 4, 4.

⁴⁴*Ibid.*

⁴⁵The new reactors are nowadays known under the names Réacteur Jules Horowitz (RJH), MYRRHA, and PALLAS.

⁴⁶'Je ne sais pourquoi on ne parle que du "medical" sans doute le lobby de Petten. Un MTR a tout intérêt à avoir un spectre étendu d'utilisateurs: dans ce sens les applications industrielles des radioisotopes et le silicium dopage ne sont pas à négliger'. In: 'Email Pol Gubel', 23 June 2002. SCK CEN Central Archive, Box 3, A, 4, 3.

⁴⁷The availability of new reactors in due time is still questionable and the appropriateness of their design for supporting nuclear medicine can be challenged'. In: Henri Bonet, 'Abstract – Availability of Test Reactors: A Key Issue for Nuclear Medicine', SCK CEN Archive BR2, C, 1, 10.

⁴⁸Bonet is zeker geen voorstander van een innovatieve reactor voor de Mo [Molybdenum] productie (ik lees Myrrha) (...) Hij zou zelfs gezegd hebben dat ADS systemen niet haalbaar zijn voor de Mo productie'. In: 'Email Jef Vanwildemeersch to Paul

not be let to believe that if 1.5 billion euros are invested in the construction of 3 reactors (...) the problem of isotopes for medical use will be solved'.⁴⁹ Instead of the large-scale plans of the French, Dutch, and Belgian research reactors, Bonet argued that radioisotopes could also be produced in smaller dedicated reactors of about 100 million euros.⁵⁰

From the onset of the Atomic Age into the early twentieth century, the politics of test reactors should be understood as an interplay between international rivalry, rising neoliberalism, and domestic politics between different regions and institutes involved in the medical nuclear industry. Although radioisotopes had always been part of the production cycles in the reactor, their position on the priority list was very much contested. However, from the late 1990s onwards, medical applications of nuclear technology would increasingly gain ground in the narratives of the Belgian Nuclear Research Centre.

Politically correct isotopes

The changing narratives surrounding the Belgian reactor were not an isolated event. While Cold War science is often equated with Big Science that was focused on large-scale single programmes, the post-Cold War era saw the rise of what some coined Big Biology, most popularly visible in the 3-billion-dollar Human Genome Project.⁵¹ Among historians of science and medicine, the rise of biotechnology from the 1970s onwards signifies an important marker of the emergent commercialisation of academic research.⁵² Old Big Science gave way to the New Big Science, characterised by 'a growing emphasis on accountability (...) government-industry partnerships and practical applications' better suited to a 'post-Cold War moral economy that values entrepreneurship and measurable utility'.⁵³ While many public research organisations, both in Europe and the U.S.A., adapted to this shifting environment through new research programmes and new experimental tools, nuclear research centres occupied a unique position in this development by having to adapt by repurposing their ageing test reactors.

Among the test reactors in the Low Countries, the shifting narrative towards medical applications was most visible at the Petten-based reactor. The hosting organisation, Nuclear Research and Consultancy Group (NRG), presented itself in the 1990s as a 'Medical Valley', appealing to the popular image of entrepreneurship connected to scientific research based on Silicon Valley.⁵⁴ New research programmes in Boron Neutron Capture Therapy (BNCT) that could utilise the reactor to treat brain tumours (glioblastoma multiforme) were widely publicised and became an explicit justification for the reactor itself, as the project leader was quoted in a Dutch newspaper: 'We hope that this will also increase support

Govaerts, Frank Deconinck, Pol Gubel', 8 March 2005. SCK CEN Archive BR2, C, 1, 10; For an elaborate history of this reactor, see: Hein Brookhuis, 'Making Belgian Big Science: A History of the MYRRHA Research Reactor (1994–2010)', *Historical Studies in the Natural Sciences*, 53, 1 (2023), 35–70.

⁴⁹Men moet de politieke wereld niet laten geloven dat wanneer er 1,5 miljard euro geïnvesteerd wordt in de bouw van 3 reactoren (J. Horowitz, Pallas en Myrrha), het probleem van de isotoopenproductie voor medisch gebruik opgelost zal zijn'. In: Meeting report *Raad van Bestuur* 248, 13 December 2006. SCK CEN Central Archive, Box 19, B, 1, 7.

⁵⁰*Ibid.*

⁵¹Niki Vermeulen, 'Big Biology. Supersizing Science During the Emergence of the 21st Century', *NTM Zeitschrift für Geschichte der Wissenschaften, Technik und Medizin*, 24 (2016), 195–223; Daniel Kevles, 'Big Science and Big Politics in the United States: Reflections on the Death of the SSC and the Life of the Human Genome Project', *Historical Studies in the Physical and Biological Sciences*, 27, nr. 2 (1997), 269–97.

⁵²Doogab Yi, *The Recombinant University. Genetic Engineering and the Emergence of Stanford Biotechnology* (Chicago, IL: University of Chicago Press, 2015); Nicolas Rasmussen, *Gene Jockeys: Life Science and the Rise of Biotech Enterprise* (Baltimore, MD: Johns Hopkins University Press, 2014); Paul Rabinow, *Making PCR: A Story of Biotechnology* (Chicago, IL: University of Chicago Press, 1996).

⁵³Robert Crease and Catherina Westfall, 'The New Big Science', *Physics Today*, 69, nr. 5 (2016), 34. See also Olof Hallonsten, *Big Science Transformed. Science, Politics and Organization in Europe and the United States* (London: Palgrave Macmillan, 2016).

⁵⁴A. Keverling Buisman and J. Heijn, 'Medical Valley. Nuclear medicine in the dunes of Petten, Netherlands; Medical Valley. Nucleaire geneeskunde in de Pettense duinen' (December 1996). See <https://www.osti.gov/etdeweb/biblio/398939> (Consulted: 6 February 2026).

for the reactor. A lot also depends on these trials for the reactor'.⁵⁵ Working closely together with medical companies and academic hospitals, the directors of NRG believed in 2003 that the support from the medical community had not only averted a shutdown of their HFR but also led to a 'favourable' social and political climate for the construction of a future new test reactor in the Netherlands.⁵⁶

The public and political benefits of a medical focus were similarly obvious to the directors of SCK CEN but the Belgian context proved to be more challenging. In 2003, director Paul Govaerts, himself a radiation protection specialist, noted that 'it is clear that the production of radioisotopes by BR2 weighs heavily on the political acceptance of this reactor' and the advisory board insisted that the growth of radiobiology and nuclear medicine should be seen as 'societally relevant opportunities for diversification' of the institute's research programme.⁵⁷ However, their strategy to shift the focus to medical research had developed 'without much success'.⁵⁸ Whereas the Dutch centre cultivated its collaborations with universities and industry, SCK CEN saw itself 'confronted with the medical research at the universities' on the one hand, and with the 'strongly technologically developed medical industry' on the other hand.⁵⁹ The post-war choice to organise nuclear research outside the existing academic structures was not easily reversed in the Belgian context.

The Belgian test reactor occupied an ambiguous position in strategic discussions. The production of radioisotopes was increasingly seen as a 'politically correct justification' for the nuclear research centre as a whole.⁶⁰ Due to the reduction in research projects since the 1980s, even former sceptics increasingly accepted the production of radioisotopes as the main priority of the reactor and this had become its main public justification in the view of marketing manager Vanwildemeersch: 'Isotope-production is admittedly not the scientific justification of the reactor, but without it we cannot justify the reactor – no matter how'.⁶¹ Financially, however, the situation was more complex. The production of radioisotopes did lead to an increase in external income, and by 2005 this roughly covered 30% of the operational costs of the reactor. Although this was insufficient to cover the full costs, it was sufficient to fulfil the political requirement that only one third of the annual subsidies were used for the reactor.⁶² Although the production of radioisotopes appealed to both the social and entrepreneurial values that New Big Science embodied, it was still far from being a commercially viable activity for research centres.

The financial structure behind radioisotope production, being funded with public money to serve a commercial pharmaceutical market, gained interest among SCK CEN's leadership only when the BR-2 obtained a larger market share around 2008. From 2008 onwards, the Canadian isotope-producing reactor (NRU) was shut down several times, and its replacement reactor (MAPLE) was cancelled.⁶³ It appeared that Canada was questioning its future commitment to reactor-produced radioisotopes. With BR-2 gaining a larger market share as a consequence, SCK CEN director Eric van Walle argued that 'the

⁵⁵Ed. 'Nieuw Imago voor Petten' *Trouw*, 3 July 1998, 5. Translation by the author.

⁵⁶[Dick Bergmans:] 'Sinds men in Nederland uitvoerig gedebatteerd heeft omtrent het bestaansrecht van de HFR (en het is de medische wereld die ervoor gezorgd heeft dat de HFR niet definitief gesloten werd) is het klimaat om in te stemmen met de bouw van een nieuwe reactor die aan bovenstaande eisen voldoet redelijk gunstig'. In: Anonymous, 'Beknopte resultaten van wederzijdse bevraging NRG/SCK CEN', 8 December 2003, SCK CEN Archive BR2 Box C, 7, 2.

⁵⁷'Het is duidelijk dat de productie van radio-isotopen door BR2 zwaar weegt bij de politieke aanvaarding van deze reactor'. Paul Govaerts, 'Herziening van het strategisch plan van het SCK CEN. Discussienota voor het Wetenschappelijk Advies Comité'. Annex to WAC 88, 28 January 2003. SCK CEN Central Archive, Box 3, B, 4, 10.

⁵⁸*Ibid.*

⁵⁹*Ibid.*

⁶⁰BR2 draagt ook bij tot een politiek-correcte justificatie van het SCK CEN via de productie van radio-isotopen voor medisch gebruik'. In: Anonymous, 'Perspectieven van de prioritaire programma's', annex to *Raad van Bestuur* 239, 23 March 2005. SCK CEN Central Archive. Box 19, A, 1, 10.

⁶¹'De isotoopenproductie is weliswaar niet de wetenschappelijke verantwoording van de reactor, maar erzonder kunnen we – gelijk hoe – de reactor niet verantwoorden'. In: 'Email Jef Vanwildemeersch, betreft: de nieuwe reactor in IRE/voorstelling Bonet op BNS meeting van 24 feb', 8 March 2005. SCK CEN Archive BR2. C, 1, 10.

⁶²'De reactor is op zich niet winstgevend. Ongeveer een derde van de overheidssubsidie (14 miljoen euro, nvdr) wordt in de werking van de BR2 gepompt'. In: 'Onderzoek bij SCK redt mensenlevens'. *Het Nieuwsblad*, 11 May 2007.

⁶³Alison Motluk, 'What Killed the Maples Reactors?', *New Scientist* 205, 2743 (2010), 30–3.

radioisotopes for the whole world are produced with Belgian government money' because the production costs of the isotopes were 'higher than their selling price'.⁶⁴ Due to the origin of test reactors as state-funded research instruments, the pharmaceutical industry had benefited by not having to pay the full production costs of the isotopes. This situation, director Van Walle believed, led to a commercial radioisotope market that was subsidised by Belgian public money.⁶⁵ From 2008 onwards, discussions surrounding radioisotope production changed from being a politically correct justification for nuclear research infrastructure to making it a financially profitable activity.

The subsidised prices of radioisotopes can be seen as a long-term consequence of what Néstor Herran called the 'paradigmatic' science policy of the Cold War, in which state-funded research formed a foundation of industrial applications.⁶⁶ The view that the economic structure of the radioisotope market was unsustainable was not only a critique from SCK CEN's director, but it was also a view held by the OECD's Nuclear Energy Agency (OECD-NEA). In 2010, they pointed out what was called the 'market-failures' of the radioisotope industry. The NEA argued that the production of radioisotopes had always been seen as a by-product of test reactors for which the full costs were never covered by its sales, but was nevertheless seen by the nuclear laboratories as a way to financially support the research projects in their reactors. The report suggested that, throughout the years, radioisotope production had become more significant in the management of the reactor, but it also indicated that the pricing structure never changed accordingly.⁶⁷ Despite these 'uneconomical' circumstances, the NEA suggested that reactors had continued to produce radioisotopes because it was understood as a service to society and part of the 'social contract' that governments had established with the medical and nuclear communities in the past.⁶⁸ The main challenge since the 1990s was that several governments had changed this social contract, discontinuing subsidies for what was now ultimately considered a commercial activity.⁶⁹ However, with an international supply chain that connected reactors, processing companies, pharmaceutical companies, and hospitals, the pricing structure of radioisotopes could not easily be changed.

The history of radioisotopes between the 1990s and the early 2000s should be understood as an era in which the stimulation of market logic in public research centres was confronted with a radioisotope industry that was based on a funding regime from the early atomic age. As the most widely used radioisotope for diagnostic purposes, these issues were particularly connected to molybdenum-99. The final section will explore how the Belgian research centre navigated the rise of therapeutic radioisotopes, where profit margins were bigger and no pre-existing structures interfered.

From big science to big pharma

The discussions analysed so far primarily revolved around the diagnostic uses of molybdenum-99. While this isotope was widely used in hospitals for diagnostic imaging techniques (SPECT), it was not considered a major growth market for test reactors. From the 1990s onwards, however, discussions in radiopharmaceuticals were increasingly characterised by optimistic expectations regarding therapeutic rather than diagnostic applications of radioisotopes.⁷⁰ Contrary to previous decades, large pharmaceutical companies now started to explore investment opportunities in radiopharmacy, a field they had

⁶⁴Hij stelt dat de radio-isotopen voor de ganse wereld met Belgisch overheidsgeld geproduceerd worden en dat de productieprij van de isotopen hoger is dan hun verkoopprijs'. In: Meeting report *Bureau* 131, 15 October 2008. SCK CEN Central Archive, Box 19, B, 1, 7.

⁶⁵Meeting report *Bureau* 133, 27 January 2009. SCK CEN Central Archive. Box 19, B, 1, 7.

⁶⁶Néstor Herran, 'The "Bounties of Our New Servant": Isotopes, Industry, and Economy Before and After Atoms for Peace', *Journal of Cold War Studies* 25, 3 (2023), 19.

⁶⁷NEA/OECD, *The Supply of Medical Radioisotopes. An Economic Study of the Molybdenum-99 Supply Chain* (Paris: OECD/NEA, 2010), 10.

⁶⁸*Ibid.*, 13.

⁶⁹*Ibid.*, 17.

⁷⁰Frost & Sullivan, 'Future of Nuclear Medicine, Part 3: Assessment of the U.S. Therapeutic Radiopharmaceuticals Market (2001–2020)', *The Journal of Nuclear Medicine*, 39, 7 (1998), 14N–27N.

previously observed reluctantly. This final section shows how local actors in Belgium reimagined their facilities and opportunities in the light of the optimistic expectations in therapeutic applications of radiopharmaceuticals.

In 1998, only four diseases in the United States were treated with what was then called ‘nuclear medicine therapy’, being thyroid cancer, hyperthyroidism, bone pain palliation, and polycythaemia rubra vera (with I-131, Sr-89, Sm-153, and P-32).⁷¹ Around the late 1990s, some market analysts expected that eight new therapies would enter the market, leading to optimistic financial forecasts: ‘The introduction of new products is expected to expand the market from \$62 million to over \$440 million by 2001’.⁷² By 2020, the market was expected to reflect 6 billion dollars. One key hurdle, however, was the ‘unreliable supply’ of radioisotopes. In the view of the American analysts, the diagnostic market was ‘very mature’ but the therapeutic ‘infant’, although both nonetheless had ‘tremendous revenue potential’.⁷³ With the reducing amount of test reactors to provide some of the needed radioisotopes, reactors and therapies became co-dependent.

The initially optimistic expectations regarding therapeutic applications were hit by a severe blow in the early 2000s. Zevalin (based on yttrium-90) and Bexxar (based on iodine-131) were initially seen as promising new radiopharmaceuticals. The clinical results were considered positive but the drugs never managed to convince the market. According to a retrospect in *The Journal of Nuclear Medicine*, radiopharmaceuticals in general suffered not only from ‘unique challenges posed by this class of drugs’, but also from ‘historical commercial failures’. The main challenge, in sum, was to convince investors and companies of the value of the radioactive drugs.⁷⁴ In 2018, radiopharmaceutical drugs were described in the journal *Annals of Oncology* as ‘one of those decade old “technologies of the future”’.⁷⁵ In that same year, *Nature*’s biotechnology section captured the same view on the history of these drugs in a slightly more optimistic way: ‘Radioactive drugs emerge from the shadows to storm the market’.⁷⁶ Between the late 1990s and late 2010s, radiopharmacy witnessed a growing interest in therapeutic applications, a development that nuclear research centres were eager to engage with.

The role of SCK CEN in the development of a new radiopharmaceutical drug illustrates that the position of a nuclear laboratory in these developments was not self-evident. As highlighted above, most developments in nuclear medicine took place outside the post-war nuclear laboratories, primarily at university hospitals and pharmaceutical industry. The post-war nuclear laboratories played a more service-oriented role, using their reactors only to produce the raw elements. This historically service-oriented role of the nuclear laboratory initially determined SCK CEN’s start in radiopharmacy in 2006, when the Norwegian biotech company Algeta collaborated with SCK CEN, mainly to obtain actinium-227 that had been produced at the Belgian reactor in the late 1960s in collaboration with *Union Minière*, a Belgian mining company that was active in Congolese uranium mines.⁷⁷ This grew into a larger project in which SCK CEN would prepare new batches of actinium-227 for the company, ultimately leading to a project in which Algeta would develop a new drug called Alpharadin (later rebranded as Xofigo) to target bone metastases, for which SCK CEN would produce new actinium-227 in their BR-2 reactor.⁷⁸ Xofigo is based on radium-223, which it derives from actinium-227.

⁷¹*Ibid.*, 17N.

⁷²*Ibid.*, 18N.

⁷³*Ibid.*, 27N.

⁷⁴Mike Sherman and Rachel Levine, ‘Nuclear Medicine and Wall Street: An Evolving Relationship’, *The Journal of Nuclear Medicine*, 60, 9 (2019), 20S–24S.

⁷⁵Roland Turck, ‘Radio-Pharmaceuticals for Cancer Treatment: Are They Ready for Prime Time Yet?’, *Annals of Oncology*, 29, 7 (2018), 1594.

⁷⁶Elie Dolgin, ‘Radioactive Drugs Emerge From the Shadows to Storm the Market’, *Nature Biotechnology*, 36, 12 (2018), 1125–7.

⁷⁷L.H. Baetsle and A. Droissart, *Production and Applications of 227-Ac* (SCK CEN Report, BLG-483, 1973). Available here: <https://inis.iaea.org/search/51115116> (Accessed 29 May 2024). For Union Minière, see: René Brion and Jean-Louis Moreau, *De la mine à Mars – la genèse d’Umicore* (Tielt: Lannoo, 2006).

⁷⁸Ivan Pittevels, ‘Interne Nota: AMFORA Historiek’, 18 July 2014. SCK CEN Central Archive. Box 19, C, 8, 1.

The outcome of the collaboration between Algeta and SCK CEN, however, reflected the new situation in which the nuclear research centre had to engage much more intensely with pharmaceutical companies than before. The expansion of the project with Algeta was coined AMFORA, which stood for Actinium for Radiopharmaceutical Applications. While this project expanded between 2009 and 2014 at SCK CEN, the international pharmaceutical company Bayer became a partner in Algeta, investing 800 million dollars in the development of the new drug Alpharadin. By 2014, an agreement under discussion between SCK CEN and Algeta represented a projected annual income for SCK CEN of about 25 million euros to be obtained between 2015 and 2019, and possibly an annual 50 million euros beyond 2019. In total, it was believed that SCK CEN could make 414 million euros with the project.⁷⁹ These numbers were much higher than those experienced before with the production of radioisotopes for diagnostic purposes, making the radiopharmaceutical market more important to strategic considerations.

The successful projects with Algeta and the conversations with Bayer motivated SCK CEN's management to further invest in their Business & Development Unit.⁸⁰ The market for radiopharmaceuticals had become a highly attractive means for SCK CEN to increase its revenue, allowing the institute to continue to operate its R&D programmes at a large scale. It was especially attractive because directors realised that there were 'very few nuclear spin-offs' available in the nuclear sector.⁸¹ Ultimately, however, the project ended in disillusion. When Bayer bought Algeta in 2014, ongoing negotiations with SCK CEN were ultimately terminated, partly reflecting the inexperience of SCK CEN in the pharmaceutical industry. In the end, SCK CEN obtained an additional income of 1.7 million euros with the AMFORA project between 2013 and 2015.⁸² A few years later, it appeared that Bayer had turned to the Oak Ridge National Laboratory in the U.S.A. for the necessary amount of actinium-227.⁸³

Despite being a disappointing outcome for SCK CEN, the project confirmed the high hopes in radiopharmaceuticals. The collaboration was proof for the institute's management that pharmaceutical companies were actively investing in radiopharmaceuticals. Bayer's commercialisation of Xofigo in 2015 is often considered a major breakthrough in radiopharmaceuticals.⁸⁴ MEDDraysintell, a Belgian consultancy company specialised in nuclear medicine, predicted a growth for the radiotherapeutic market from 300 million euros in 2014 to possibly 11 billion euros by 2030, predictions that the directors of SCK CEN were well aware of.⁸⁵ Meanwhile, the institute also experienced the increasing value of radioisotopes at the BR-2 reactor, where the income from radioisotopes had increased between 2006 and 2013, primarily due to prices that had now tripled.⁸⁶

The optimistic market development led to an increasing amount of medical projects at SCK CEN. The plan to refurbish the BR-2 reactor in 2012 to extend its lifetime was explicitly justified by SCK CEN's role in the radioisotope market.⁸⁷ Strategic considerations in the institute reflected the importance of the medical orientation in a similar way. The new strategic plan aimed to focus on domains 'in which success is fairly guaranteed', and the development of new therapeutic radioisotopes was now considered as one of them.⁸⁸ Next to new radioisotopes, directors also aimed to climb up the value chain for existing

⁷⁹ Meeting report *Bureau* 170, 8 October 2014. SCK CEN Central Archive. Box 19, B, 6, 2.

⁸⁰ Ivan Pittevels, 'BD&S aanpak valorisatie', annex to *Raad van Bestuur* 285, 22 October 2014. SCK CEN Central Archive. Box 19, B, 6, 2.

⁸¹ Meeting report *Raad van Bestuur* 285, 22 October 2014. SCK CEN Central Archive. Box 19, B, 6, 2.

⁸² Meeting report *Raad van Bestuur* 287, 1 February 2015. SCK CEN Central Archive. Box 19, B, 1, 10.

⁸³ 'ORNL Ramps up Production of Key Radioisotope for Cancer-Fighting Drug', May 31, 2018. Available at <https://www.ornl.gov/news/ornl-ramps-production-key-radioisotope-cancer-fighting-drug>. Accessed 16 August 2024.

⁸⁴ Dolgin, *op. cit.* (note 76).

⁸⁵ MEDDraysintell, 'Nuclear Market Report 2015', cited in meeting report *Bureau* 186, 1 February 2017. SCK CEN Central Archive. Box 19, B, 1, 12.

⁸⁶ Meeting report *Raad van Bestuur* 279, 26 June 2013, SCK CEN Central Archive. Box 19, B, 6, 3.

⁸⁷ Steven van Dyck, 'Investeringsplan voor het verzekeren van de continuïteit van de uitbating BR2 tot 2026', 15 March 2012. SCK CEN Central Archive. Box 19, B, 7, 10.

⁸⁸ Annex to *Bureau* 169, 11 June 2014. SCK CEN Central Archive. Box 19, B, 6, 2.

radioisotopes by investing in new chemical facilities. The higher SCK CEN could get in the value chain of the radioisotopes, the more revenue they could obtain.⁸⁹ Market developments therefore altered traditional institutional arrangements, as the nuclear research centre now partly explored opportunities that were traditionally covered by academic hospitals and processing companies such as the I.R.E.

An important consequence of these developments is that strategic considerations were more explicitly tailored to market-oriented arguments. A priority was the production of actinium-225, which was chosen because it could lead to a 'true niche' for SCK CEN in the medical world. In 2024, this was described in the *Financial Times* as a 'rare isotope that could redefine cancer care'.⁹⁰ Other candidates were rhenium-188 and terbium-161 isotopes, partly because the then widely demanded lutetium-177 was considered to be 'hyped and investigated/applied by many others', and SCK CEN had thus already 'missed the boat'.⁹¹ All of them were developed for therapeutic purposes. Although rhenium and terbium were considered to be less interesting from the perspective of long-term financial growth potential, they offered faster development and a shorter 'time-to-revenue'.⁹² Contrary to the production of molybdenum-99, SCK CEN now also planned to implement the radiochemical processes after the initial production, and especially these facilities were considered 'the money maker' for the research centre.⁹³ Radioisotopes to be developed and facilities to be installed were thus partly selected on criteria related to their financial prospects in the pharmaceutical market.

Stepping into the medical industry also meant a step into a very competitive environment, an environment in which a nuclear research centre may not always feel comfortable. The competitive nature of the market partly steered the scientific interests and strategic decisions regarding their facilities. The test reactor, lamented as a money-losing venture throughout the 1980s and early 1990s, was now considered a 'point of differentiation' and therefore a competitive advantage in the radiopharmaceutical market.⁹⁴

Conclusion

Test reactors nowadays play a major role in political and commercial debates on the supply of medical radioisotopes. Since 2022, the European Commission has been working on what is coined the 'European Radioisotope Valley Initiative', an initiative to secure the safety, innovation, and supply of radioisotopes in Europe, in which reactors play an important role. While reactors have rarely received this attention in the past, neither from policymakers nor academic historians, this article has argued that the history of test reactors is crucial to understand how scientific, political, and commercial actors shaped the contemporary market of medical radioisotopes.

The history of test reactors, as explored in this article through the case of the Belgian BR-2, can be divided into three phases. The first phase was characterised by the Cold War context of the Atoms for Peace programme, in which the United States used its technological and economic prowess to supply Western European countries with American-designed reactors. Understood as research infrastructure for large-scale nuclear programmes, the operational costs of test reactors were covered by government funding. The second phase that can be distinguished, from the 1960s onwards, reflects a phase of international projects among European countries, projects that were important to justify and valorise the large government funds. The ending of fast reactor projects in the 1980s introduced the third

⁸⁹ Ivan Pittevels, 'Interne nota: presentatie BD&S aan MC en Raad van Bestuur', Annex to *Raad van Bestuur* 285, 22 October 2014. SCK CEN Central Archive. Box 19, B, 6, 2.

⁹⁰ 'The Hunt for a Rare Nuclear Isotope that could Redefine Cancer Care', *Financial Times*, 27 July 2024. Available at <https://www.ft.com/content/6ce668bc-4180-4e84-9feb-f25ac0e83f6f>. Accessed 16 August 2024.

⁹¹ 'MYRRHA Progress Update: MMT in Collaboration with Medical Campus Task Force', Annex to *Bureau* 186, 1 February 2017. SCK CEN Central Archive. Box 19, B, 1, 12.

⁹² *Ibid.*

⁹³ 'Radio-Isotopes Irradiation Marketing Plan for BR2', annex to *Raad van Bestuur* 306, 13 June 2018. SCK CEN Central Archive. Box 19, B, 1, 14.

⁹⁴ *Ibid.*

phase, an era that is characterised by international competition among reactors to obtain international projects.

The emergence of radioisotopes as a central strategic focus of nuclear research centres reflects important continuities and discontinuities between these three phases. Institutional narratives continued to emphasise the international status that the Belgian BR-2 had in the 1960s and 1970s, even when political and industrial developments had severely undermined that status by the 1980s. A focus on radioisotopes was therefore highly contested, as a production-oriented role did not fit with the self-perceived importance of the reactor as an international site for experimental research.

The most important continuity that this article has identified is the long-lasting impact of post-war science funding. While current historiography tends to draw sharp distinctions between public research funding pre- and post-1980s, reflecting the impact of neoliberal policies on public research institutions, the pre-1980s funding logic shaped markets that continued to rely on that logic well into the twenty-first century. The production of radioisotopes is therefore a phenomenon that fits oddly with the introduction of market logic at public research centres in the 1980s. While reactors indeed had to adapt to a more competitive environment, radioisotopes were not understood as a commercially viable product, primarily because of the history of subsidisation of test reactors.

Consequently, this article has shown that practices of nuclear medicine are strongly entangled with post-war politics and governance, entanglements that have survived supposed transitions between various policy regimes.

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