# Nuclear Science and Higher Education

A Brief Case Study of the Massachusetts Institute of Technology Nuclear Research Reactor Laboratory: The Economic Benefits of Developing a Victorian Nuclear Science and Engineering Sector

Submission for the Victorian Legislative Council Inquiry into Nuclear Prohibition

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# 1. SUMMARY

This case study seeks to answer Question 2, "(2) identify economic, environmental and social benefits for Victoria, including those related to medicine, scientific research, exploration and mining;" within the Terms of Reference agreed upon regarding the Inquiry into Nuclear Prohibition, from the perspective of the impact of lifting the prohibition on nuclear technologies on the Higher Education sector. It will explore the potential economic and scientific benefits to Victoria's Higher Education via a case study of the nuclear research laboratory at the Massachusetts Institute of Technology in Cambridge, MA. This paper seeks to propose that a Victorian university, or universities, would increase their comparative advantage (or, competitive edge) over other universities in Australia by developing the appropriate research and technology facilities, including a fully functioning nuclear reactor. It will argue that Victoria is in an excellent position to build a modern reactor with all of the passive safety features included in modern nuclear facilities, including the zero-chance possibility of catastrophic accidents resulting in radioactive contamination.

# 2. NUCLEAR RESEARCH LABORATORY AS AN ECONOMIC BENEFIT

## 2.1 THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY'S NUCLEAR RESEARCH REACTOR & LABORATORY

I have chosen this particular case study because of the immense economic and scientific benefits that a nuclear reactor facility, with accompanying laboratory, in a tertiary education context, has to scientific research across multiple high-value economic fields.

MIT is a global leader in scientific and technological development, boasting cutting edge research facilities that have spearheaded development in fields such as Artificial Intelligence, Space Exploration and Robotics. The MIT NRR (Nuclear Research Reactor) directly creates 6MW of electricity for the facility's use and provides numerous other research opportunities for medicine, industry, and science.

Among these include, but are not limited to: neutron analysis in geological samples; medical research, including such recent trials as the "boron neutron capture therapy" to treat brain tumours and skin cancer; materials testing, such as alloys and alternative industrial substances; fission engineering; nuclear equipment training and certification; physics laboratory equipment testing, such as new lasers and particle testing.

## 2.2 ECONOMIC CONTRIBUTION

MIT has calculated its direct economic impact, through its various entrepreneurial, scientific and business ventures, to be valued over USD$2 trillion. By comparison, Australia's GDP value stands at USD$1.4 trillion. The NRR contributes an estimated $100 billion to this figure through the development of its own research communities, new nuclear technologies, and direct contribution to energy decarbonisation, among other programs. The high value of the research and technology products created contribute significantly to the high value of MIT's NRR as an engine of economic growth.

### 2.2.1. ECONOMIC CONTRIBUTION – INTERNATIONAL STUDENTS

The prestige of MIT as a global leader also attracts over 3,400 international students (of a total of 11,000 students), suggesting that international students make up about 30% of its total student body. Foreign exchange students in the US make up an average of 5% of the total student body across the nation. In the US, 51% of international students attend STEM courses, of which 21.1% attend engineering alone. Nuclear Science and Engineering are well-poised to take advantage of this trend in the rising popularity of STEM subjects.

By comparison, the average Australian university is comprised of 22% international students. Education exports account for a larger share of income for Australian Universities, and thus it is important to observe this trend and continue to provide knowledge services for international students.

The total economic impact of education exports is currently valued at $32 billion, of which approximately $11.9 billion belongs to Victorian universities, according to an Aug 2019 report. As a result, nuclear science and engineering facilities in Victorian universities would be well-placed to take advantage of international trends towards STEM degree popularity among international students.

### 2.2.2. ECONOMIC CONTRIBUTION – NEW AND EMERGENT INDUSTRIES

As previously stated, MIT's global economic impact is estimated at $2 trillion through various entrepreneurial and emerging industry initiatives and the activities of its alumni. This figure is important to our examination as it represents the potential value of high technology investment in tertiary education.

In contrast, Australia's "Group of 8" universities as a whole directly contribute $66.4 billion of economic activity and $24.8 billion in research value. Victoria's Go8 Universities, The University of Melbourne and Monash University, may represent future opportunities for industrial research. The potential returns of nuclear facilities at a Go8 University may represent an additional AUD$3 to $5 billion to the Victorian economy, through international students and new industrial involvement. This figure may become exponentially higher with an established industry.

### 2.2.3. NUCLEAR MEDICINE

Currently, the Lucas Heights Nuclear Facility creates over 85% of Australia's nuclear medicine needs and is one of 11 worldwide nuclear reactors capable of creating much-needed radioisotopes for nuclear medicine. The global market for nuclear medicine was valued at USD$6.1 billion in 2019 and is estimated to grow to at least USD$12.7 by 2027. Future projections for radiopharmaceuticals place Australia in a prime position currently to take advantage of this growth, if the moratorium on nuclear technologies is lifted.

# 3. COSTS ASSOCIATED WITH CONSTRUCTION AND MAINTENANCE

## 3.1. CONSTRUCTION

Construction of the Nuclear Reactor facility began in 1956 at the cost of USD$3 million. This translates to USD$27 million in 2020 figures, or AUD$40 million. By comparison, Southern Cross University in Lismore, NSW, allocated and spent a comparative sum of $40 million on upgrading its sports facilities to an Olympic-grade Sports and Aquatics facility.

## 3.2. MAINTENANCE AND REFUELING

The MIT NRR costs USD$2.5 million per year (in 2020) to refuel. MIT replaces fuel 3-4 times per year, however, it acknowledges that this is not needed and it could theoretically replace fuel every few decades (due to the high energy density of nuclear fuel). Refuelling is conducted for the benefit of gaining experience for engineering staff and students.

## 3.3. COSTS SUMMARY

The price of constructing a modern nuclear facility can vary widely. A small research reactor may cost between the tens to hundreds of millions of dollars for construction and installation, however, the price of refuelling the reactor is minuscule. Capital works across the tertiary education sector are normally valued within a similar range, leading towards the conclusion that given the appropriate investment, a University or group of investors would experience expedient returns on the initial investment, given the high-value nature of products created by nuclear processes, such as nuclear medicine and scientific research.

Further research into this should be conducted because it is beyond the scope of this document. The purpose of the pricing listed is to demonstrate that a research reactor should not be prohibitively expensive.

# 4. PERCEPTIONS

## 4.1. NEGATIVE PERCEPTIONS AS AN OBSTACLE TO NUCLEAR TECHNOLOGY

These negative perceptions should be acknowledged in the debate concerning lifting the moratorium on nuclear technology, as much of the negative perception against nuclear energy and technology is informed by harmful superstitions rather than scientific facts.

## 4.2. "THE YUCK FACTOR"

Coined in the 1990s by anti-water-treatment activists, news media reported that the biggest obstacle to the widespread implementation of treated water for drinking in Australia is the appropriately named "Yuck" factor. That is, the repulsion of drinking water filtered from "black water" waste is interpreted by a layperson as greater than the benefit of drinking pure water. In a similar fashion, an equally irrational fear of nuclear waste materials and unsubstantiated claims of toxicity play a larger role in opinions and perception regarding electricity generation and research where nuclear technology is involved.

An excellent example of this in play is the unrealised fears surrounding the Lucas Heights nuclear reactor and facility: despite providing life-saving nuclear medicine technologies and research, news media and anti-nuclear activists stoke irrational fears about unproven safety concerns.

## 4.3. FAKE NEWS AND CULTURAL INFLUENCES

The most common sources of misinformation and "fake news" concerning nuclear energy come from social media and pop culture.

During the Fukushima nuclear accident in Japan, it was common for anti-nuclear activists to share a hydrographical image of the total tsunami reach across the Pacific but relabelled to imply it was an official record of "radioactive fallout". Despite the zero human deaths and small, localised incidents on some wildlife, the site itself was the target of fake news from activists hoping to stoke irrational fear of nuclear technology.

Another common source of misconceptions is the popular television cartoon “The Simpsons”, where the main character demonstrates zero understanding of common OHS practices concerning safe disposal of nuclear waste (portrayed as sludge in barrels, rather than pellets in self-contained alloy rods), and the nuclear facility is used as a convenient plot device for dangerous accidents and suspense. It is not a realistic portrayal of nuclear operations; however, it’s often cited by the layperson as their only source of information concerning nuclear technology.

## 4.4. DRAMATISATION OF NUCLEAR ACCIDENTS

The recent dramatisation of Chernobyl by Netflix helped to reignite the debate about the safety record of nuclear energy. Despite being the single safest source of energy, accounting for 90 deaths per terawatt hour of energy (compared to 150 for wind, 440 for solar, 4000 for natural gas, and 100,000 for coal), nuclear energy receives harsher responses and facilitates a negative bias from many people.

# 5. CONCLUSION

## 5.1. SUMMARY

The economic benefits of a nuclear research reactor are obvious, from supporting high-value industries to medical research and high technology engineering. From a brief review of the MIT NRR facility, we can conclude that this world-class facility can draw international students — a key source of revenue for Australian Universities — and it can act as part of a greater mix of entrepreneurial ventures that increase the net worth of the economy through the creation of scientific communities and business/industry partnerships.

A similar facility at an Australian University may make it possible to increase home-grown research capabilities, nurture new decarbonisation technologies, grow new entrepreneurial ventures, and firmly establish local knowledge centres in the field of nuclear science and engineering. Beyond increasing the $11.9 billion share of economic benefit from international students in Victoria, the potential benefit to emerging new technology and high-value industries in Australia would allow further economic diversification. Key among this would be the introduction of technologies aimed at decarbonising the energy and industrial sectors, improved energy efficiency, and the growth of Australia's scientific community within important sectors of industry and research.

## 5.2. FURTHER EXPLORATION

This case study briefly touched upon numerous key and strategic benefits that home-grown nuclear industrial expertise may bring, such as decarbonisation of the energy and industrial sectors. The scope of this document does not permit a comprehensive research and analysis project to determine the full potential of the benefits and challenges touched on here. The author recommends that any serious endeavour undertake a full cost/benefit analysis to accurately assess the variables concerning an emerging nuclear technologies sector.

# 6. REFERENCE LINKS

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