A Nuclear Error — But I Have No Fear? Assessing whether the Time has Come for New Zealand to Embrace Nuclear Energy

Brendan Abley*

New Zealand does not currently use nuclear sources to produce electricity. In 1978 a Royal Commission of Inquiry concluded that New Zealand would not need to consider nuclear power as an option until the 21st century. This article revisits the Royal Commission's conclusions, and analyses whether the time has come for New Zealand to reconsider its position on nuclear energy. The article carries out this analysis in light of the Government's recent goals of providing energy security and minimising greenhouse gas emissions. In doing so, the article reviews the current legal regime for nuclear technologies and considers the Canadian regulatory framework as a model for future developments. It then assesses New Zealand's likely future electricity needs, and whether New Zealand can meet these needs with renewable sources. The article considers whether nuclear energy would be a better option to meet the energy challenges of the 21st century.

1. INTRODUCTION

Nuclear energy burst into the world's consciousness in the middle of the 20th century. From its violent birth as an engine of destruction during the Second World War, nuclear energy for a brief period came to epitomise the potential of science to improve wellbeing. Proponents of the technology affirmed that nuclear power would herald the dawn of a "third great epoch in human

*The author is a graduate of The University of Auckland. This article is a modified version of a dissertation submitted for the degree of Bachelor of Laws (Hons) at The University of Auckland in June 2015. Email: brendanabley@gmail.com.

history"[1] — an era of abundance in which electricity would be "too cheap to meter".[2] Sixty years later, much of this optimism has eroded in the face of accidents, environmental concerns and the problem of radioactive waste.

Nuclear energy enjoyed a brief "renaissance" in the first decade of the 21st century. Increasing concerns about climate change, along with rising fossil fuel prices, meant that nuclear energy again started to find favour as a more benign option to meet the world's electricity needs.[3] The Fukushima Daiichi disaster of 2011 has set back this fleeting rebirth — but many countries are likely to continue unabated with their nuclear ambitions.[4]

In this article, I consider whether New Zealand should do the same. New Zealand is not immune to the energy challenges that the world currently faces. Energy security and climate change have become the defining issues of the age. In part 2 of this article, I discuss New Zealand's nuclear history, and outline how New Zealand's refusal to develop nuclear energy was shaped as much by economic factors as anti-nuclear sentiment. Part 3 then considers the current legal position on nuclear energy and demonstrates that New Zealand does not actually ban nuclear energy — in fact, a basic regulatory regime is already in place. In part 4, I assess Canada's legislative framework to illustrate how New Zealand could further develop its own laws to manage a functioning nuclear power industry.

I subsequently move to New Zealand's policy stance on nuclear energy in part 5. New Zealand rejects nuclear energy at present. It has done so since 1978, when the Royal Commission of Inquiry into Nuclear Power Generation (the Royal Commission) concluded that New Zealand did not need nuclear power — for the time being. The Royal Commission stated unequivocally that New Zealand would need to revisit the issue of nuclear energy by the 21st century. Accordingly, parts 6 to 8 assess whether the time has indeed come for New Zealand to reconsider its stance. I have broken this question down into three discrete issues. Part 6 analyses New Zealand's likely future demand for electricity. Part 7 then considers whether renewable sources are a realistic option to meet future demand. This analysis will establish that renewables could meet New Zealand's electricity needs comfortably. Nevertheless, recent proposals

1 Homi Babha "The Peaceful Uses of Atomic Energy" (1955) 11 Bulletin of the Atomic Scientists 280 at 282.

2 Lewis Strauss, Chairman of the United States Atomic Energy Commission (Speech to the National Association of Science Writers, New York, 17 September 1954).

3 Paul Joskow and John Parsons *The Future of Nuclear Power After Fukushima* (MIT Centre for Energy and Environmental Policy Research, February 2012) at 6–7.

4 At 20 and 26.

demonstrate that there may not be the political will to actually capitalise on this potential. Part 8 tackles the question of whether nuclear energy could enable New Zealand to meet its electricity needs in an environmentally responsible way.

Ultimately, I conclude that New Zealand does not need to go down the nuclear road. However, the world faces difficult energy choices in the 21st century. New Zealand is no exception. We must fully consider all alternatives if we are to meet the energy challenges that the future holds.

2. A BRIEF FLIRTATION WITH THE ATOM: NEW ZEALAND'S NUCLEAR PAST

2.1 Early Enthusiasm for Nuclear Technologies

New Zealand embraced many early nuclear technologies when they first became available in the early decades of the 20th century.[5] This enthusiasm extended to nuclear electricity generation, with an Atomic Energy Committee formed in 1958.[6] By the 1960s, New Zealand's existing electrical infrastructure was struggling to meet demand.[7] The Government began to look at options to meet the looming shortfall. Opinion at the time was divided between either putting off nuclear energy in favour of developing indigenous renewable resources (namely hydroelectricity), or investing immediately in nuclear installations.[8]

By 1965, plans were under way to build a nuclear power station north of Auckland.[9] The New Zealand Electricity Department's (NZED) Nuclear Power Siting Committee (established in 1964) had flagged a suitable location on the Kaipara Harbour. Its proximity to Auckland would make electricity transmission relatively cheap, yet the site was far enough away to mitigate the effects of any potential accidents. The plant could draw water from the nearby Waitakere Ranges and discharge wastewater into the harbour.[10] The project did not proceed. In the 1970s the Maui gas field and additional coal deposits were discovered, revealing that New Zealand had more indigenous energy resources

5 For a comprehensive and interesting overview of New Zealand's adoption of many early nuclear technologies see, in particular, ch 1 of Rebecca Priestley *Mad on Radium: New Zealand in the Atomic Age* (Auckland University Press, Auckland, 2012).

6 Andrew McEwan *Nuclear New Zealand: Sorting Fact from Fiction* (Hazard Press, Christchurch, 2004) at 38.

7 Priestley, above n 5, at 187.

8 At 187–188.

9 At 185.

10 At 185.

than expected.[11] This demonstrates that economic considerations, not overriding anti-nuclear sentiment, drove New Zealand's energy decisions in the 1960s and 1970s.[12]

Nevertheless, nuclear power remained on the agenda through the 1970s. The NZED's Planning Committee on Electric Power Development called for a "decision in principle" on the issue by the year 1977 — enough time to commission a reactor by 1990 if needed.[13] By this stage, however, public opinion had also begun to turn against nuclear energy.[14] Against this background, the Government established the Royal Commission.

2.2 The 1978 Royal Commission of Inquiry

Ultimately, the Royal Commission deferred the question of whether New Zealand should proceed to develop nuclear capabilities. I have set out the Royal Commission's own summary of its conclusions in Appendix A to this article. Its key findings were:[15]

- New Zealand's indigenous generation resources would be sufficient until the 21st century. New Zealand should develop those resources as far as economically and environmentally sensible.
- Based on the economic growth and electricity demand trends of the time, the country would likely need nuclear power by the 21st century.
- Provided that waste disposal methods could be found and suitable sites chosen, no other single aspect of nuclear power generation should result in nuclear power being rejected.
- New Zealand should proceed on the basis that nuclear energy would be needed in the future.

As the 21st century enters its sixteenth year, it is therefore appropriate to revisit the nuclear question.

11 At 200.
12 At viii.
13 McEwan, above n 6, at 42.
14 Priestley, above n 5, at 202–203.
15 Thaddeus McCarthy and others *Royal Commission on Nuclear Power Generation in New Zealand* (Government Printer, April 1978) at 57–58 [Royal Commission].

3. THE CURRENT LEGAL REGIME

3.1 Overview

New Zealand uses many nuclear technologies. Each year, there are about 2,500 instances of nuclear material imports into New Zealand (excluding smoke alarms), totalling approximately $4 million.[16] Nuclear technology finds its way into medical applications such as x-rays, radiotherapy treatment and equipment sterilisation.[17] Radioactive materials are used in several industrial processes and have research and development applications.[18] Some consumer goods (such as the ubiquitous smoke alarm) contain negligible amounts of radioactive material.[19] New Zealand's "nuclear free" stance obviously does not extend to all nuclear technologies. Surely, then, some form of regulation must exist to govern these activities. As it turns out, New Zealand already has a legal regime for nuclear technologies, which I will review in this part of the article. This analysis reveals that the assertion of a "nuclear free" New Zealand does not accurately describe New Zealand's legal position.

3.2 Regulating Nuclear Technology at National Level

3.2.1 The Atomic Energy Act 1945

The title of the Atomic Energy Act 1945 (AEA) states that it is "An Act to make provision for the *control* in New Zealand of the means of producing atomic energy" (emphasis added).[20] Section 12 of the AEA restricts nuclear power installations. It states:[21]

> **12 No person to possess fissionable substances, etc, without consent**
>
> …
>
> (2) No person shall *without the prior written consent of the [Minister of Science and Innovation]*,[22] import, construct, have in his possession or control, or operate any machine, atomic pile, or apparatus which may be capable of producing atomic energy … [emphasis added]

16 McEwan, above n 6, at 14; Priestley, above n 5, at ix.
17 McEwan, above n 6, at 15.
18 At 15.
19 At 15.
20 Atomic Energy Act 1945 [AEA], Title.
21 AEA, s 12.
22 The Act refers to the Minister of Science, Research and Technology. This now means the Minister of Science and Innovation, as outlined in s 2 of the AEA.

It is important to note that this is a restriction, not an outright prohibition, on the construction or operation of a nuclear reactor. In theory, a person could obtain consent (under the AEA, at least) to construct and operate a nuclear device.

Ownership of all uranium existing in its natural state in land is vested in the Crown under the Crown Minerals Act 1991.[23] This places the fuel materials that would be necessary for nuclear processes on the same footing as gold, silver and petroleum in terms of being reserved to the Crown. The AEA further controls the possession and trade of uranium and other "prescribed substances".[24] The Minister responsible for the Ministry of Business, Innovation and Employment (MBIE) must consent to any disposition of materials containing prescribed substances that have been extracted, isolated, or concentrated.[25] This means that trading in the materials necessary for nuclear processes is controlled (but again, not prohibited) by statute.

It is illegal to import more than 5 pounds of any prescribed substance, without consent from the Minister for MBIE.[26] It is also illegal to import, or even possess, plutonium or other substances that can be used to produce nuclear energy more readily than natural uranium, without consent from the Minister of Science and Innovation.[27] Trading in processed nuclear fuel without consent from the Minister of Science and Innovation is prohibited.[28] It is also illegal to import, manufacture, possess, or control any material or substance that is incidental to nuclear energy production without consent.[29] As a result, the AEA restricts radioactive material that has been processed in some way to make it more useful in producing nuclear energy.

The upshot of the AEA is that it allows many nuclear activities to legally take place, subject to controls. Consequently, the AEA actually provides a (basic) regulatory framework for nuclear technologies and associated materials, substances and equipment.

3.2.2 The Radiation Protection Act 1965

The Radiation Protection Act 1965 (RPA) controls the importing and use of radioactive materials. As an aside, it is the RPA and not the Hazardous Substances and New Organisms Act 1996 that deals with radioactive materials.[30]

23 Crown Minerals Act 1991, s 10.
24 AEA, s 2.
25 Section 6(1). The AEA defines "Minister" as the Minister responsible for administering the Act. The Act is currently administered by the Ministry of Business, Innovation and Employment.
26 Section 7.
27 Section 12(1).
28 Section 14.
29 Section 12(3).
30 *Thresholds and Classifications Under the Hazardous Substances and New Organisms Act 1996* (Environmental Protection Authority, January 2012) at 7.

The Ministry of Health administers the RPA. The RPA appears to be concerned more with the medical applications of radioactive material. Regardless, the RPA makes it illegal to manufacture, sell, import, export, store, or transport any radioactive material without consent from the Minister of Health.[31] This consent may be subject to conditions.[32] The RPA also empowers the Governor-General to issue regulations for nuclear technologies. Section 31 of the Act contains a fairly exhaustive list of the matters that these regulations can address. A number of these matters would apply to a nuclear power plant.[33]

The Radiation Protection Regulations 1982 (RP Regulations) restrict a number of activities to do with radioactive substances. The RP Regulations require operators to transport radioactive material in accordance with the International Atomic Energy Agency (IAEA) Transport Regulations.[34] If there is any uncontrolled release of radioactive material, the person holding the licence to deal with that material must take reasonable steps to recover the material and minimise the potential harm that may result.[35] The RP Regulations also cover safe storage and disposal of radioactive material and any vessels used to contain it.[36] If a licensee considers that an area is hazardous as a result of radioactive materials or equipment, the licensee must designate the area as a "controlled area" and take steps to prevent access to it.[37]

3.2.3 The New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act 1987

The New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act 1987 (Nuclear Free Zone Act) prohibits some applications of nuclear technology in New Zealand. Section 4 of the Act creates a nuclear free zone (the Zone) that extends across New Zealand's land, airspace and waters, out to the limits of the territorial sea.[38] The Nuclear Free Zone Act expressly prohibits the following nuclear activities across the entire Zone:

31 Radiation Protection Act 1965, s 12(1).
32 Section 12(2).
33 See the matters set out in Radiation Protection Act, s 31.
34 Radiation Protection Regulations 1982, reg 3. Regulation 2 of the Radiation Protection Regulations defines "IAEA Transport Regulations" as the Regulations for the Safe Transport of Radioactive Materials, published in 1973. The IAEA's site lists the current regulations as published in 2012.
35 Regulation 11(2).
36 See regs 12, 14 and 15.
37 Regulation 21.
38 New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act 1987 [Nuclear Free Zone Act], s 4.

- manufacturing, acquiring, possessing, or controlling any *nuclear explosive device*; [emphasis added][39]
- stationing, transporting, or deploying any nuclear explosive device;[40] and
- testing any nuclear explosive device.[41]

The Nuclear Free Zone Act also prohibits nuclear powered ships from entering New Zealand's internal waters.[42] However, the Act conspicuously does not prohibit a land-based nuclear reactor that could be used to generate electricity.[43] When he introduced the New Zealand Nuclear Free Zone, Disarmament, and Arms Control Bill (Nuclear Free Zone Bill), then-Prime Minister David Lange emphasised that the Bill was designed to ensure the "exclusion of nuclear weapons from New Zealand" and a "disengagement" from nuclear strategy as a means of defence.[44] This suggests a focus on military, not civilian, applications of nuclear technology, as reflected in the Nuclear Free Zone Act's title:[45]

> An Act to establish in New Zealand a Nuclear Free Zone, to promote and encourage an active and effective contribution by New Zealand to the essential process of disarmament and international arms control and to implement in New Zealand [a number of treaties].

The Nuclear Free Zone Bill contrasts with an alternative proposal — the Nuclear Free New Zealand Bill[46] which explicitly stated that it was "desirable" to prohibit nuclear power stations.[47] The Bill would have prohibited nuclear devices and nuclear weapons in New Zealand.[48] It also would have prohibited dealing with nuclear waste within New Zealand.[49] The Nuclear Free New Zealand Bill passed its first reading, but did not progress further.[50]

39 Nuclear Free Zone Act, s 5. Section 2 of the Nuclear Free Zone Act defines a "nuclear explosive device" as a nuclear weapon or other explosive device capable of releasing nuclear energy.
40 Section 6.
41 Section 7.
42 Section 11.
43 World Nuclear Association "Nuclear Energy Prospects in New Zealand" (June 2014) <www.world-nuclear.org>.
44 David Lange (10 December 1985) 468 NZPD 8910.
45 Nuclear Free Zone Act, Title.
46 Nuclear Free New Zealand Bill 1984 (136-1).
47 See the preamble to the Nuclear Free New Zealand Bill.
48 Clause 4.
49 Clause 5.
50 See (25 September 1985) 466 NZPD 7040 and Garry Knapp (16 October 1986) 475 NZPD 5000–5001.

3.3 Regional Controls on Nuclear Energy

The legal position changes at local level. The Resource Management Act 1991 (RMA) requires each regional council to prepare a regional policy statement (RPS) setting out objectives and policies for resource management in the region.[51] Six regional councils explicitly prohibit electricity generation from nuclear plants. Table 1 summarises the status of nuclear energy under the current RPS for each regional council.

Table 1: Regional Policy Statements — position on nuclear energy

Regional council	**Status of nuclear energy production**
Northland	Prohibited[52]
Auckland	Prohibited[53]
Waikato	Not mentioned
Bay of Plenty	Not mentioned
Gisborne	Not mentioned
Hawke's Bay	Not mentioned
Taranaki	Not mentioned
Manawatu-Wanganui	Not mentioned
Wellington	Not mentioned
Tasman	Prohibited[54]
Nelson	Prohibited[55]
Marlborough	Not mentioned
West Coast	Not mentioned
Canterbury	Not mentioned
Otago	Prohibited[56]
Southland	Prohibited[57]

51 Resource Management Act 1991, ss 60(1) and 62(1).
52 Regional Policy Statement for Northland 1999, Policies 28.3(2) and 28.4(3).
53 Auckland Regional Policy Statement 1999, Policy 5.4.4(2). See also Proposed Auckland Unitary Plan 2013, Chapter H4.1: Air Quality, Activity Table.
54 Tasman Regional Policy Statement, Policies 12.3(b) and 12.4.
55 Nelson Regional Policy Statement 1997, r DH3.3.1.
56 Regional Policy Statement for Otago 1998, Policy 12.5.1.
57 Operative Southland Regional Policy Statement 1997, Chapter 5.14, Policy 14.7.

As an illustration, I now examine the policy position in the Auckland and Waikato regions in more detail.

3.3.1 Auckland

Despite being New Zealand's most populous city and largest commercial and industrial centre, Auckland's operative[58] RPS is unambiguously opposed to nuclear energy. It reads:[59]

> … the failure of a nuclear power generation plant or nuclear powered system could have widespread and severe effects on the environment. The current government's anti-nuclear policies are therefore supported in order to prevent the introduction of nuclear energy into New Zealand.

This statement does not accurately interpret the national legislative position on nuclear energy. Still, it is the rationale behind the Auckland Regional Council's ban on nuclear power stations. Policy 5.4.4(2) of the RPS states:[60]

> Nuclear propelled ships *and the construction of nuclear power* stations shall be prohibited within the Auckland Region. [emphasis added]

The Auckland Council is currently reviewing the RPS as it develops the Proposed Auckland Unitary Plan (PAUP). The PAUP lists nuclear power generation as a "prohibited" activity in all areas.[61]

3.3.2 Waikato

The Waikato Regional Council does not expressly prohibit nuclear energy in its RPS.[62] The region's proposed RPS also does not mention nuclear energy.[63] Waikato's policy position is relevant because of the region's importance to New Zealand's electricity system. On the banks of the northern reaches of the Waikato River sits the Huntly Power Station. With 1,203.8 megawatts (MW) of generating capacity, this coal- and gas-fired behemoth is capable of supplying

58 This is the RPS currently in force for Auckland. The incoming Auckland Unitary Plan will supersede the existing RPS.

59 Auckland Regional Policy Statement, Issue 5.2.4.

60 Auckland Regional Policy Statement, Policy 5.4.4(2).

61 Proposed Auckland Unitary Plan 2013, Chapter H4.1: Air Quality, Activity Table.

62 See Waikato Regional Policy Statement 2000.

63 See Proposed Waikato Regional Policy Statement Decisions (November 2012), Annotated with Environment Court Appeals (1 February 2015).

approximately 20 per cent of New Zealand's current electricity needs.[64] Genesis Energy, the plant's owner, summarises the site's advantages:[65]

> This station is located close to major population centres, has reliable access to cooling water, coal and gas resources, and benefits from limited transmission constraints … The Huntly Power Station has the ability to provide base-load generation while also being able to take advantage of higher prices in the short or medium term.

Its proximity to Auckland and ready access to water and transmission infrastructure make the Huntly site a good location for any power station. As noted above, almost identical factors led the NZED to nominate the Kaipara Harbour site as suitable for a nuclear power plant.[66] If New Zealand ever did choose to invest in nuclear energy, the Waikato region has the appropriate policy framework, and a potentially viable site for a nuclear power station.

3.4 Conclusions on New Zealand's Legal Position

Two conclusions emerge about New Zealand's legal regime. First, existing legislation in New Zealand restricts, but does not prohibit, nuclear energy as a means of generating electricity. Secondly, if New Zealand invests in nuclear energy, legislation that already exists could provide the beginnings of a functioning regulatory regime.

There is some disconnect between nation-wide legislation and local government policies, with some local authorities expressly prohibiting nuclear power. If central government decided to adopt policies in favour of nuclear power, it would need to address this inconsistency. The Government could, for example, issue a national policy statement (NPS) under the RMA in favour of nuclear energy. A NPS sets out objectives and policies to achieve the RMA's sustainable management purpose.[67] Local authorities must update their own planning instruments to "give effect to" a NPS.[68] Consequently, if the New Zealand Government decided to adopt nuclear energy, it could issue a NPS to override any anti-nuclear provisions in local government instruments.

64 Genesis Energy "Huntly Power Station" (2015) <www.genesisenergy.co.nz>.
65 Genesis Energy, above n 64.
66 Priestley, above n 5, at 185.
67 Resource Management Act, s 45(1).
68 Section 55.

4. WHAT WOULD AN EXPANDED NUCLEAR REGULATORY REGIME LOOK LIKE? THE CANADIAN EXAMPLE

In this part of the article, I will outline key elements of the Canadian framework for regulating nuclear energy. Canada's regime illustrates legislative measures that a nuclear-powered New Zealand would likely need to implement.

Canada generates 15 per cent of its electricity from 19 nuclear reactors.[69] It has a comprehensive set of statutes that govern various aspects of the nuclear energy process. Based on the Canadian example, a regulatory regime for nuclear energy would need to cover the following areas:

- procurement and transport of nuclear fuel;
- a consent process to build, operate and decommission power plants;
- liability for accidents;
- storage and disposal of nuclear waste; and
- security and protection against terrorist acts.

Table 2 lists the existing New Zealand statutes that could apply to each of these areas.

Table 2: Existing legislation

Part of process	**Existing statute**
Procurement of nuclear fuel	Atomic Energy Act 1945, Crown Minerals Act 1991
Transport of nuclear fuel	Radiation Protection Act 1965
Environmental management and the consent process to build, operate and decommission power plants	Atomic Energy Act 1945, Resource Management Act 1991
Liability for accidents	No specific statute (Accident Compensation Act 2001 would have a role)
Storage and disposal of nuclear waste	Radiation Protection Act 1965
Security and protection against terrorist acts	Terrorism Suppression Act 2002, Crimes Act 1961

Due to space constraints, I have limited my analysis in this part to Canada's consent processes, environmental management regime and liability for

69 World Nuclear Association "Nuclear Power in Canada" (June 2015) <www.world-nuclear.org>.

accidents. I will consider Canada's approach to managing radioactive waste and terrorism in part 8. I do not cover procurement and transport of nuclear fuel, although effective nuclear legislation would need to address those issues.

4.1 Consent Processes

4.1.1 The Canadian framework

The Nuclear Safety and Control Act SC 1997 c 9 (NSCA) and the Canadian Environmental Assessment Act SC 2012 c 19 (CEAA) regulate nuclear reactor proposals.

The NSCA's purpose is to limit the risks associated with nuclear technologies "to a reasonable level".[70] Section 26 of the NSCA prohibits the following key activities without a licence:[71]

- dealing with nuclear-related substances or equipment;
- processing nuclear substances;
- producing or servicing nuclear-related equipment; and
- constructing, operating, decommissioning, or abandoning a nuclear facility.

The NSCA establishes the Canadian Nuclear Safety Commission (CNSC) as the nuclear regulator.[72] The CNSC may issue licences to carry out the activities that s 26 of the NSCA prohibits.[73] The CNSC must consider that the applicant is qualified to carry out the activity and will adequately protect the environment, health and safety, and national security.[74] The CNSC can attach conditions to licences.[75] The CNSC must hold a public hearing before it issues licences.[76]

The NSCA also establishes procedures for accidents and emergencies. If the CNSC suspects that radioactive contamination has occurred, it can hold a public hearing to determine the existence and extent of that contamination.[77] The CNSC can then direct the owner or manager of the site to reduce the level of contamination.[78] In the event of an emergency, the CNSC has additional broad powers. It can make any orders that it considers necessary to protect

70 Nuclear Safety and Control Act SC 1997 c 9 [NSCA], s 3.
71 Section 26.
72 Section 8.
73 Section 24(1).
74 Section 24(4).
75 Section 24(5).
76 Section 40(5).
77 Section 46(1).
78 Sections 46(1) and (3).

Canada's environment, the health and safety of its population, and its national security.[79]

The CEAA is a broader piece of environmental protection legislation. Its purpose is to protect the environment from possible adverse effects of "designated projects". Nuclear-related activities, including fuel processing, reactor construction and waste management, are designated projects.[80] The CEAA seeks to assess these activities in a precautionary way that allows public input.[81]

The CEAA requires the CNSC to carry out an environmental assessment for any nuclear energy activity, and report on its findings.[82] The CNSC can delegate its functions to a panel.[83] The CNSC's assessment must evaluate the environmental impacts of the proposal, including the potential effects of malfunctions and accidents.[84] The assessment must also take into account cumulative effects, comments from the public, and any technically and economically feasible mitigation measures or alternatives to the project.[85] The assessment must take into account any follow-up programme that may be required to remedy the proposal's environmental impacts.[86] The CNSC has to give the public an opportunity to participate in the assessment process.[87]

The CNSC must then conclude whether the designated project is likely to have significant environmental effects.[88] If the answer is yes, the CNSC then has to refer the matter to the Governor-in-Council, who decides whether the effects are justified in the circumstances.[89] The CNSC or Governor-in-Council must impose conditions on the applicant in either case.[90]

4.1.2 Necessary reforms to New Zealand's environmental management framework

In New Zealand, the RMA contains similar regulatory approval procedures for large projects. A proposal for a nuclear power plant would require "resource

79 Section 47(1).
80 Canadian Environmental Assessment Act SC 2012 c 19 [CEAA], s 2. Nuclear energy activities are included in the list of designated projects in Regulations Designating Physical Activities SOR/2012-47, regs 31–38.
81 CEAA, s 4.
82 Sections 13, 15 and 22.
83 NSCA, s 22.
84 CEAA, s 19(a).
85 Sections 19(a), (c), (d) and (g).
86 Section 19(e).
87 Section 24.
88 Sections 27(1) and 52(1).
89 Sections 52(2) and (4).
90 Sections 53(1), (2) and (4).

consent" under the RMA — but as it stands this legislation would be a critical stumbling block to a nuclear proposal.

Part 2 of the RMA sets out the Act's purpose and key principles. Appendix B to this article sets out pt 2 in full. The RMA's purpose as defined in s 5(1) is to "promote the sustainable management of natural and physical resources". Section 5 further defines "sustainable management" as:[91]

> … managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—
> (a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
> (b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
> (c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Part 2 also addresses energy matters. Section 7 requires decision-makers to "have particular regard to" a number of "other matters", which include:[92]

- the efficiency of the end use of energy;
- the effects of climate change; and
- the benefits to be derived from the use and development of renewable energy.

A 2004 amendment to the RMA inserted these factors.[93]

An application to build a nuclear power plant would invoke the decision-making criteria set out in s 104 of the RMA. Section 104 states (relevantly):

> **104 Consideration of applications**
> (1) When considering an application for a resource consent and any submissions received, the consent authority must, *subject to Part 2*, have regard to—
> (a) any *actual and potential effects* on the environment of allowing the activity; and

91 Resource Management Act, s 5(2).
92 Sections 7(ba), (i) and (j).
93 Resource Management (Energy and Climate Change) Amendment Act 2004.

(b) any relevant provisions of [a number of national, regional and local planning instruments]; and
(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application. [emphasis added]

In particular, the decision-maker would have to consider the possible effects of a reactor accident. These effects would fall within the category of effects that have a low probability but high potential impact — which the RMA recognises in s 3(f). Consequently, the decision-maker would have to take into account a possible accident, along with the duty under pt 2 of the Act to promote sustainable management.[94] Although improbable, the high potential impact of a reactor accident would likely force decision-makers under the RMA to take a conservative approach.

Admittedly, cases decided under the RMA acknowledge that "everybody lives with some risk every second of their lives … the RMA is not a 'no risk statute'".[95] There is some tolerance for risk under the RMA. The "other matters" in pt 2 that relate to energy could also work in favour of a nuclear reactor proposal (although nuclear energy would not qualify as a renewable energy source as currently defined in the Act).[96]

On balance, however, obtaining resource consent to build a nuclear power plant would be a long and difficult process. If New Zealand did adopt nuclear energy, Parliament would have to reform the RMA considerably to ensure nuclear proposals could obtain regulatory approval. Alternatively, a specific statute for nuclear proposals (similar to the NSCA) would be needed. In any event, this legislation would have to find an appropriate balance between enabling nuclear energy to proceed and keeping risks to an acceptable level.

4.2 Liability Limits

The cost of a single nuclear accident could be as much as $300 billion.[97] In consequence, most electricity companies and insurers would be reluctant to invest in nuclear technology without some form of protection. Various domestic laws and international conventions, such as the Vienna Convention on Civil

94 Resource Management Act, s 5.
95 *Shirley Primary School v Telecom Mobile Communications Limited* [1999] NZRMA 66 at [105]–[106].
96 Resource Management Act, s 2.
97 See *Future Currents: Electricity Scenarios for New Zealand 2005–2050* (Parliamentary Commissioner for the Environment, 2005), endnote 94 at p 90.

Liability for Nuclear Damage, regulate nuclear operators' liability to third parties. These laws are based on the following general principles:[98]

- strict liability;
- exclusive liability for the operator of the institution;
- mandatory financial coverage for the operator's liability; and
- limitation of liability to a certain amount of money and for a certain period of time.

Until 2015 in Canada, the Nuclear Liability Act RSC 1985 c N-28 (NLA) limited civil liability for nuclear damage to C$75 million.[99] The new Nuclear Liability and Compensation Act SC 2015 c 4 (NLCA) has increased the limit to C$1 billion.[100] The NLCA imposes absolute liability on operators.[101]

One criticism of capped liability is that it could operate as an "implicit subsidy" for the nuclear industry. Electricity generators only have to maintain insurance up to a set level, which reduces their insurance premiums.[102] Under Canada's former $75 million liability limit, this implicit subsidy could have been anything up to 3.58 Canadian cents per kilowatt hour (KWh).[103] Opponents therefore argue for the removal of liability limits, as electricity prices should reflect the true cost of generation.[104]

Strict liability does have some merits. It reduces the need for victims to prove fault in the event of an accident,[105] as the Royal Commission noted.[106] Further, limited liability perhaps represents a tacit acknowledgement that the state assumes a risk when it allows nuclear energy. The state that makes that choice gains the benefits of nuclear energy — proponents of a liability limit argue that the state should also socialise the associated risks.[107]

Ultimately, the Royal Commission stated that it would prefer New Zealand to avoid a "guarantee without limit" for damage arising from a nuclear accident.[108] A "strict but capped" framework, although controversial, would be

98 World Nuclear Association "Liability for Nuclear Damage" (April 2015) <www.world-nuclear.org>.

99 Nuclear Liability Act RSC 1985 c N-28, s 15.

100 Nuclear Liability and Compensation Act SC 2015 c 4, s 24(1).

101 Section 10.

102 Joel Wood "Regulation review: Canada's nuclear liability" (May/June 2011) Fraser Forum 35 at 35.

103 Anthony Heyes and Catherine Heyes "An empirical analysis of the Nuclear Liability Act (1970) in Canada" (2000) 22 Resource and Energy Economics 91 at 97.

104 Wood, above n 102, at 36.

105 World Nuclear Association, above n 98.

106 Royal Commission, above n 15, at 221.

107 World Nuclear Association, above n 98.

108 Royal Commission, above n 15, at 228.

the most likely approach to liability if New Zealand did choose to invest in a nuclear energy programme.

5. NEW ZEALAND'S POLICY POSITION ON NUCLEAR ENERGY

5.1 The Existing Policy Position

The World Nuclear Association (WNA) lists New Zealand as "one of the few developed countries not using electricity (indigenous or imported) from nuclear energy".[109] This statement is strictly true — but New Zealand still imports products from countries where nuclear energy is part of the manufacturing process. Also, claiming "nuclear free" status ignores the (not insignificant) imports of radioactive materials that have been manufactured in overseas reactors. Accordingly, New Zealand's "nuclear free" claims, based on its rejection of weapons, ships and power plants, could present a "blinkered" approach to the issue.[110]

Successive policy documents reject — or are silent on — the nuclear option. In 2007 the Ministry of Economic Development (MED) released the New Zealand Energy Strategy to 2050 (NZES 2050). NZES 2050 devotes an entire paragraph to nuclear energy.[111] Although it acknowledges that new reactor designs are safer and cheaper, MED states that nuclear power remains more expensive than other options. Furthermore, questions remain about other negative aspects such as reactor accidents, natural disasters and terrorist attacks. Radioactive waste and potential military uses are also matters for concern. As a result of this exhaustive analysis, NZES 2050 concludes that New Zealand's Government should remain opposed to nuclear power.[112] The Government has subsequently released the New Zealand Energy Strategy 2011–2021 (NZES 2011) — which does not mention nuclear energy as an option.[113]

The Parliamentary Commissioner for the Environment (PCE) released *Future Currents: Electricity Scenarios for New Zealand* in 2005. *Future Currents* at least contains a full appendix on nuclear energy. It states that nuclear power generation is unlikely to take off in New Zealand. Even if it did, *Future Currents* notes some concerns about nuclear power, including dangers

109 World Nuclear Association, above n 43.
110 McEwan, above n 6, at 14.
111 *New Zealand Energy Strategy to 2050* (Ministry of Economic Development, October 2007) at 19 [NZES 2050].
112 At 19.
113 See *New Zealand Energy Strategy 2011–2021* (Ministry of Economic Development, August 2011) [NZES 2011].

from radioactive waste and the consequences of an accident. Additionally, questions remain about whether nuclear power is practical and economically viable. Its purported environmental benefits are also not certain.[114]

5.2 Time for a Rethink?

> *New Zealand, like the rest of the world, faces two major energy challenges. The first is to respond to the risks of climate change by reducing the greenhouse gases caused by the production and use of energy. The second is to deliver clean, secure, affordable energy while treating the environment responsibly.*
>
> — New Zealand Energy Strategy to 2050[115]

> *From now on, all our energy choices are hard.*
>
> — Dr Paul Callaghan[116]

I now turn to assess whether New Zealand has indeed made a "nuclear error" by rejecting nuclear power. The New Zealand Government has identified two energy challenges for the future. The first challenge is to guarantee energy security. The second is to address climate change.[117] In the next three parts of this article, I will consider whether nuclear energy could enable New Zealand to address those challenges. Parts 6, 7 and 8 will consider three questions:

- how much electricity is New Zealand likely to need in the future? (part 6);
- can New Zealand rely on renewable energy sources to meet this need? (part 7); and
- would nuclear energy be a better alternative? (part 8).

The answers to these questions should inform any debate about the nuclear option for New Zealand.

6. HOW MUCH ELECTRICITY WILL NEW ZEALAND NEED IN THE FUTURE?

Most sources estimate that New Zealand's electricity use will increase at a rate of between 1 and 2 per cent each year up to around the year 2050. In 2014

114 *Future Currents*, above n 97, at 83.
115 NZES 2050, above n 111, at 8.
116 Paul Callaghan, Foreword to Andrew McEwan, above n 6, at 9.
117 NZES 2050, above n 111, at 12–14; NZES 2011, above n 113, at 2.

New Zealand consumed 39,187 gigawatt hours (GWh) of electricity. This was slightly less than the amount of electricity generated — 42,214 GWh.[118]

6.1 Projections of Future Electricity Use

6.1.1 Future Currents

Future Currents reviews New Zealand's electricity use trends and sets out options to meet or change the country's future electricity use. It assumes that demand for energy services will continue to increase at a rate of 2 per cent annually.[119] This is based on previous electricity use trends.[120] "Energy services" are the outcomes that people desire from their energy use (such as heat, light and transport). Electricity is just one method to achieve these outcomes. So, increases in demand for energy services will not necessarily translate into more demand for electricity. This is possible if energy efficiency improves.[121]

Future Currents outlines two potential scenarios that describe how New Zealand's electricity use could change in the future. The first scenario ("Fuelling the future") assumes that the quest for economic growth and higher living standards will continue to push up demand for electricity.[122] If this scenario plays out, New Zealand will need 52,000 GWh of electricity by 2025, 70,000 GWh by 2040, and 84,000 GWh by 2050.[123] In the second scenario ("Sparking new designs"), improved energy efficiency means that New Zealand's projected electricity use flatlines.[124] In this scenario, electricity demand increases to approximately 40,000 GWh in 2015 and remains stable from that point onward.[125]

Arguably, *Future Currents* overestimates the likely percentage growth in New Zealand's electricity use. It drew its annual increase figure of 2 per cent from past trends. Annual growth has since slowed to an average of 0.5 per cent each year as a result of a weaker global economy and the Christchurch earthquakes.[126]

118 *Data tables for electricity* (Ministry of Business, Innovation and Employment, 10 June 2015) <http://www.med.govt.nz/sectors-industries/energy/energy-modelling/data/electricity>.
119 *Future Currents*, above n 97, at 32.
120 See *Future Currents*, above n 97, endnote 54 at p 88.
121 At 12–13. See also endnote 54 at p 88.
122 At 35.
123 At 43. Values are approximate.
124 At 38–39.
125 At 43. Values are approximate.
126 *New Zealand's Energy Outlook: Electricity Insight* (Ministry of Business, Innovation and Employment, nd) at 5.

6.1.2 Ministry of Business, Innovation and Employment: Electricity Insight

MBIE's "business as usual" scenario ("Mixed Renewables") projects electricity demand out to 2040. This scenario assumes that the costs of existing generation technology will remain stable and that New Zealand's domestic energy supply will not change significantly.[127]

In the Mixed Renewables scenario, MBIE predicts that demand for electricity will grow at 1.1 per cent each year. If this projection transpires, New Zealand will need approximately 44,000 GWh of electricity in 2025 and just over 50,000 GWh of electricity in 2040.[128]

MBIE's *Electricity Insight* also contains projections for "High Growth Sensitivity" and "Low Growth Sensitivity" variations.[129] Table 3 summarises the results.

Table 3: Summary of MBIE's projections[130]

Scenario	**Projected annual increase in electricity use**	**Projected annual electricity use in 2025 (GWh)**	**Projected annual electricity use in 2040 (GWh)**
Mixed Renewables	1.1 per cent	44,000	52,000
High Growth Sensitivity	1.3 per cent	45,000	50,000
Low Growth Sensitivity	0.9 per cent	42,000	46,000

6.1.3 New Zealand Energy Strategy to 2050

NZES 2050 predicts that electricity demand will increase at 1.3 per cent each year — the same rate as MBIE's High Growth Sensitivity projection. At this rate, NZES 2050 states that New Zealand will need to develop 3,900 MW of new generation capacity by the year 2030.[131]

127 At 3.
128 At 7. Values are approximate. Converted from terawatt hours.
129 At 5.
130 At 7. Values are approximate. Converted from terawatt hours.
131 NZES 2050, above n 111, at 72.

6.1.4 Centre for Advanced Engineering

In 2004 the Centre for Advanced Engineering (CAE) released New Zealand's load growth from 1974 and expected demand to 2025. This report predicts that average load growth will be 1.75 per cent annually.[132] The CAE predicted that by 2025 New Zealand would use 60,700 GWh of electricity each year. This is higher than the other estimates that I have cited, but the CAE report also factored in demand that off-grid generation currently meets.[133]

The CAE report predicted that by 2025 New Zealand would need to be able to produce an additional 31,122 GWh of electricity. To meet this demand, New Zealand would require new generation assets with a capacity of 6,384 MW.[134] This figure is also much higher than the other reports, but the CAE also factored in the need to provide reserve capacity. Reserve capacity is needed when existing assets are out for maintenance, or in dry years when hydroelectric output falls. The CAE concluded that New Zealand would need a 20 per cent reserve capacity for these periods.[135] Additionally, the CAE report noted that New Zealand would have to retire and replace a number of stations by 2025.[136]

6.2 Summary

Table 4 presents the projected percentage annual increase in electricity use from each report. Where the report outlined different scenarios, I have used the scenario that the report identified as representing the "status quo" approach, where current trends do not change dramatically. I used this to obtain an average projected percentage annual increase.

Table 4: Summary of projected annual percentage increases in electricity use[137]

Report	**Projected percentage annual increase in electricity use**
PCE: *Future Currents*	2 per cent
MBIE: *Electricity Insight*	1.1 per cent
MfE: NZES 2050	1.3 per cent
CAE: *Load growth*	1.75 per cent
Average	1.54 per cent

132 Bryan Leyland *New Zealand's load growth from 1974 and expected demand to 2025* (Centre for Advanced Engineering, August 2004) at 8.

133 At 9.

134 At 9.

135 At 9.

136 At 9. The CAE report said that the following stations would need to be replaced: Huntly, New Plymouth, Stratford (Taranaki Combined Cycle), Otahuhu B and Southdown.

137 Summary of results from the above reports.

I then used this average percentage to predict New Zealand's energy demand in 2025, 2040 and 2050, using New Zealand's electricity demand in 2014 (39,187 GWh) as a baseline. This is an imprecise analysis, but indicates how New Zealand's electricity demand could increase in the future. Table 5 shows the results.

Table 5: Projected electricity demand in 2025, 2040 and 2050

Year	**Projected annual electricity use (GWh)**
2014	39,187
2025	46,361
2040	58,305
2050	67,932

At this projected rate of growth, New Zealand could therefore require as much as 67,932 GWh of electricity by the year 2050 — an increase of approximately 73 per cent over the 2014 demand figure.

7. CAN NEW ZEALAND MEET ITS ELECTRICITY NEEDS WITH RENEWABLES?

Renewable sources generated over 75 per cent of New Zealand's electricity in 2013.[138] The Government has established a target for New Zealand to generate 90 per cent of its electricity from renewable sources by 2025.[139] Due to space constraints, I have limited my analysis to hydroelectricity, wind, geothermal and tidal generation, with a brief mention of solar. In analysing these sources, two questions emerge about renewable energy:

- is enough undeveloped renewable potential technically available to meet New Zealand's electricity needs?; and
- even if renewables could meet New Zealand's electricity needs, are these options politically feasible?

138 *Energy in New Zealand 2014* (Ministry of Business, Innovation and Employment, 2014) at 55.

139 NZES 2050, above n 111, at 22; NZES 2011, above n 113, at 6.

7.1 Is Enough Undeveloped Renewable Potential Technically Available to Meet New Zealand's Needs?

7.1.1 Hydroelectric energy potential

New Zealand's dependency on hydroelectric resources means that the electricity system is vulnerable to shortages (and subsequent reliance on fossil fuels) in dry years.[140] Potential hydroelectric shortages are a pressing issue, as the country's dams have a relatively low storage capacity of approximately 34 days.[141]

Estimates of New Zealand's hydroelectric resource vary greatly. NZES 2050 estimates that hydro could economically produce an additional 5,800 GWh per year.[142] A 2004 report commissioned by the MED estimated that 2,460 MW of additional hydroelectric capacity, capable of generating 11,700 GWh per year, was available.[143]

A later report for the Electricity Commission identified 18 potential hydro schemes. The report assessed these schemes according to a set list of criteria, including technical merit, transmission connection, environmental impacts, and probability of obtaining resource consents.[144] The report concluded a "short list" of eight potential schemes, with an aggregate capacity of 1,293 MW.[145]

In summary, New Zealand appears to have additional hydroelectric capacity, but any projects are likely to be smaller than in the past.[146]

7.1.2 Wind energy potential

New Zealand is well situated for wind developments.[147] Nevertheless, NZES 2050 only estimated that an additional 9,200 GWh per year of electricity could be generated economically from wind.[148] By contrast, a 2008 Connell Wagner

140 NZES 2050, above n 111, at 13.

141 IG Mason, SC Page and AG Williamson "A 100% renewable electricity generation system for New Zealand utilising hydro, wind, geothermal and biomass resources" (2010) 38 Energy Policy 3973 at 3974.

142 NZES 2050, above n 111, at 73. The MfE defines "economic" as less than 9 cents per kilowatt hour.

143 *Waters of National Importance — Identification of Potential Hydroelectric Resources* (East Harbour Management Services, January 2004) at 2.

144 *Transmission to Enable Renewables: Potential NZ Hydro Schemes — Final Report* (Parsons Brinckerhoff Associates, December 2007) at 15–17.

145 At 18–19.

146 Geoff Kelly "History and potential of renewable energy development in New Zealand" (2011) 15 Renewable & Sustainable Energy Reviews 2501 at 2502.

147 At 2503.

148 NZES 2050, above n 111, at 73.

study divided New Zealand's wind capacity into three tranches, according to the expected cost per megawatt hour (MWh). Table 6 summarises the results.

Table 6: New Zealand's wind power potential[149]

Tranche	**Cost per MWh (NZ$)**	**Available resource (MW)**	**Available resource (GWh/year)**
1	75–90	14,490	50,780
2	90–105	13,840	42,420
3	105–125	12,990	34,170
Total		41,320	127,370

It is clear that wind energy has enormous potential. The available assessed resource in Tranche 1 alone represents 125 per cent of New Zealand's electricity use in 2014.[150]

A key technical issue with wind is that it can be prone to fluctuations.[151] Regardless, a 2010 study confirmed that an energy mix that relied on wind producing 22 to 25 per cent of New Zealand's electricity would provide a stable replacement to the current system.[152]

7.1.3 Geothermal energy potential

Again, New Zealand's additional geothermal capacity is not certain. NZES 2050 estimated that geothermal energy could economically provide an additional 11,100 GWh per year of electricity.[153] Some reports estimate that 635 MW of geothermal capacity may be available.[154] The New Zealand Geothermal Association doubles this estimate, assessing the country's additional available geothermal potential at 1,235 MW.[155]

A key technical limitation on geothermal energy is that extraction must remain below a certain threshold if it is to continue. As an illustration, simulations at the Wairakei field estimate that current rates of production will

149 *Transmission to Enable Renewables: Economic wind resource study — Electricity Commission* (Connell Wagner, March 2008) at 12–13.
150 *Data tables for electricity*, above n 118.
151 Kelly, above n 146, at 2503.
152 Mason, Page and Williamson, above n 141, at 3983.
153 NZES 2050, above n 111, at 73.
154 Mason, Page and Williamson, above n 141, at 3976.
155 New Zealand Geothermal Association "Development Potential" (2014) <www.nzgeothermal.org.nz>.

exhaust the field within 100 years. The field will take approximately 400 years to "recharge".[156] Questions therefore remain as to whether geothermal energy is a truly "renewable" source. While the RMA includes geothermal energy in its definition of renewable energy,[157] exploitation of geothermal resources can only take place subject to limits — or the resource runs out.

7.1.4 Tidal energy potential

Future Currents noted that New Zealand's tidal range would probably not be suitable for electricity generation.[158] Nevertheless, there is significant movement of water in many large harbours along the west coast.[159]

Tidal energy can be difficult to quantify, as there can be discrepancies between the amount of energy that tides produce, and the amount that existing technology can economically convert to electricity.[160] Even so, a 2008 report prepared for the Energy Efficiency and Conservation Authority (EECA) suggests that 500 MW of electricity may be available with existing technology.[161] The report states that these figures are indicative only and do not reflect an in-depth economic analysis.[162]

Tidal (and other marine energy sources such as wave generation and ocean currents) could have enormous potential. Marine energy sources are close to consumers, produce more energy in winter (when demand is higher), emit no greenhouse gases, and have minimal visual impact.[163] The technology is still immature, but could contribute greatly to New Zealand's electricity system in the future.[164]

7.1.5 Solar energy potential

Solar energy may have considerable untapped potential. Although New Zealand's climate is less favourable to solar energy than other forms of renewable generation, the three major population centres (Auckland, Wellington and Christchurch) have annual insolation levels ranging from 1,300 to 1,580

156 Kelly, above n 146, at 2506.
157 Resource Management Act, s 2.
158 *Future Currents*, above n 97, at 22.
159 Deborah Johnson "Electricity and the Environment — Current Trends and Future Directions" (2005) 12 NZJEL 195 at 228.
160 *Development of Marine Energy in New Zealand* (Power Projects Ltd, June 2008) at 30.
161 Power Projects Ltd aggregates these reports in *Development of Marine Energy in New Zealand*, above n 160, Table 4.1 at 31.
162 At 30.
163 Johnson, above n 159, at 230.
164 At 230.

KWh per square metre.[165] For perspective, these insolation levels exceed those of Germany, which has still invested considerably in solar energy development.[166]

7.1.6 So does New Zealand have the renewable capacity to meet its needs?

The short answer is — on a technical level, yes. New Zealand's renewable potential is more than capable of providing the extra generation capacity discussed in the projections above. Table 7 summarises the potential generation capacity of hydro, wind, geothermal and tidal energy.[167]

Table 7: Summary of New Zealand's additional renewable capacity

Resource	**Lower estimate (MW)**	**Upper estimate (MW)**
Hydro	1,293	2,460
Wind	14,490 (Connell Wagner assessment, Tranche 1 only)	41,320 (Connell Wagner assessment, Tranche 1, 2 and 3)
Geothermal	635	1,235
Tidal	500	500
Total	16,918	45,515

These figures comfortably exceed the estimated future demand discussed in part 6 of this article. The 2010 study referenced above (under 7.1.1 Hydroelectric energy potential) concluded that renewables could reliably provide 100 per cent of New Zealand's generation capacity, thus displacing the fossil fuels that currently generate approximately 25 per cent of the country's electricity.[168]

7.2 Policy Support for Renewable Electricity Generation

On a theoretical level, New Zealand legislation and government policy is geared toward supporting renewable projects. Any major generation project will likely need resource consent under the RMA.[169] When deciding resource consent applications, decision-makers must have particular regard to the matters in s 7. The benefits to be derived from renewable energy is one of these matters.[170]

165 Kelly, above n 146, at 2506.
166 At 2506.
167 Due to a lack of clear projections, solar energy is not included in these estimates.
168 Mason, Page and Williamson, above n 141, at 3983.
169 Johnson, above n 159, at 215.
170 Resource Management Act, s 7.

In addition, the Government has also released a National Policy Statement for Renewable Electricity Generation (NPSREG).[171] The NPSREG contains policies to facilitate development of new and existing renewable generation assets. It seeks to increase the proportion of renewable generation up to the Government's target of 90 per cent.[172]

As a result, New Zealand's legislative and policy framework should, in theory, favour renewable electricity developments. Ironically, renewable proposals are still likely to face an arduous regulatory approval process.[173]

7.3 Political Barriers to Renewable Development

Bluntly, the renewable options that I have analysed all come at an environmental cost. The Royal Commission summed up the problem in 1978 when it stated:[174]

> … whether New Zealand can do without nuclear power does not depend on governmental action alone. To achieve that, the people of this country will have to accept the environmental consequences of enlarged programmes of hydro, geothermal and coal development … If New Zealand wants more electricity, and we are sure it will, some environmental price will have to be paid.

Increasing demand for electricity has run up against public unwillingness to accept major generation projects, even from renewable sources.

7.3.1 Hydroelectricity

Hydroelectricity has served New Zealand well, but most viable sites have already been developed. Many remaining potential sites sit within conservation areas.[175] Hydroelectric projects have extensive environmental effects, including effects on water quality and ecosystems. Hydro schemes also raise issues of water rights.[176] Accordingly, hydroelectric proposals are likely to face considerable opposition. To illustrate, in 2001 Meridian Energy outlined plans for a new hydroelectric scheme for the Waitaki River. Meridian abandoned the

171 *National Policy Statement for Renewable Electricity Generation 2011* (Ministry for the Environment, 14 April 2011).

172 *National Policy Statement for Renewable Electricity Generation 2011*, above n 171, at 4.

173 Kelly, above n 146, at 2504.

174 Royal Commission, above n 15, at 41.

175 *Future Currents*, above n 97, at 22.

176 Simon Schofield "The Law of Climate Change Mitigation in New Zealand" (LLM thesis, University of Canterbury, 2012) at 92.

project in the face of widespread public opposition, having spent close to $95 million.[177]

A similar fate befell a more recent proposal from Contact Energy, another operator. In 2008 Contact announced that it would assess new hydro schemes on the Clutha River. The company backed down in 2012, citing economic factors.[178] Environmental groups celebrated the decision, stating that the days of large-scale hydro projects were over.[179]

7.3.2 Wind

Wind faces significant barriers to development.[180] Large-scale wind farms involve sacrifices in terms of land use and amenity values. These barriers explain why wind energy has not made more of an impact on New Zealand's electricity scene.

Applicants may have to go to court to gain resource consent. In *Genesis Power Limited v Franklin District Council*, Genesis applied for resource consent to build 18 turbines on the Awhitu Peninsula. In the Environment Court's view, the only significant adverse effect of the proposal would be the visual impact of the wind farm on the surrounding landscape.[181] The Court noted that the 2004 amendments to s 7 (which inserted the references to climate change and renewable energy) were a clear signal to promote renewable generation projects.[182] The Environment Court granted resource consent for the proposal, but Genesis abandoned the project.[183] Obtaining resource consent therefore does not guarantee that the scheme will go ahead.

A similar tale unfolded in *Maniototo Environmental Society Incorporated v Central Otago District Council*. Meridian Energy applied for resource consent to build and operate a far larger wind farm (176 turbines) in Central Otago, named Project Hayes. The Environment Court concluded that the project would be "inappropriate" in the surrounding landscape.[184] Following a High Court appeal[185] (where the case was sent back to the Environment Court), Meridian

177 At 94.

178 "Contact calls halt to Clutha hydro plans" *The New Zealand Herald* (online ed, Auckland, 1 May 2012).

179 "Contact Energy drops plans for Clutha dams" Radio New Zealand (online ed, New Zealand, 1 May 2012).

180 Kelly, above n 146, at 2503.

181 *Genesis Power Limited v Franklin District Council* [2005] NZRMA 541 at [108].

182 At [220].

183 New Zealand Wind Energy Association "Awhitu" <www.windenergy.org.nz>.

184 *Maniototo Environmental Society Incorporated v Central Otago District Council* (Environment Court, C103/09) at [757]; Simon Schofield "Geothermal and Wind Energy in New Zealand" (2013) 17 NZJEL 155 at 181.

185 *Meridian Energy Limited v Central Otago District Council* [2011] 1 NZLR 482.

withdrew its application. The company has stated that withdrawing the proposal was the "most prudent commercial decision" available.[186]

These cases demonstrate that wind farm proposals will face significant legal and political barriers. Even if the applicant wins out in court, there will still be significant political pressure not to proceed with the development.

7.3.3 Geothermal

As discussed above, geothermal energy is sensitive to over-exploitation, which drives political opposition. To illustrate, overdevelopment of sites near Rotorua during the 1980s resulted in many geysers and hot springs drying out.[187] This ultimately led to restrictions on geothermal bores.[188] A further issue with geothermal development is that it may conflict with the cultural significance that Māori place on geothermal resources.[189] Cultural concerns are an additional factor that any proposals to further develop geothermal resources must take into account.

7.3.4 Tidal

Even tidal projects face opposition. A tidal power company, Crest Energy, had to appeal to the Environment Court twice to gain resource consent for a 200 MW array in the Kaipara Harbour. In the first decision, the Environment Court stated that the proposal would promote sustainable management, particularly in light of the RMA amendments that prioritised renewable energy.[190] Despite this positive assessment, the Court delayed resource consent until Crest could present an acceptable Environmental Management Plan to mitigate the effects of the proposal.[191] In 2011 the Environment Court granted resource consent.[192] Nonetheless, Crest dropped the project in 2013. It joined a swathe of other tidal energy generators who shelved their projects around the same time. Industry operators cited factors ranging from an uncertain electricity market, political barriers, and opposition from councils and local communities.[193]

186 Meridian "Meridian withdraws resource consents for Project Hayes" <www.meridianenergy.co.nz>.

187 Kelly, above n 146, at 2505.

188 Schofield, above n 176, at 109; Schofield, above n 184, at 161.

189 Kelly, above n 146, at 2506.

190 *Crest Energy Kaipara Limited v Northland Regional Council* (Environment Court, A139/2009) at [207].

191 At [222] and [294].

192 *Crest Energy Kaipara Limited v Northland Regional Council* [2011] NZEnvC 26, [2011] NRMA 420.

193 Anthony Doesburg "Plug pulled on tidal turbine projects" *The New Zealand Herald* (online ed, Auckland, 6 November 2013).

7.3.5 Solar

A 2009 report commissioned by MED lists a number of key issues affecting the uptake of solar energy. These include the upfront capital costs of installing solar technology, a lack of clear public information, and building approval processes.[194] The report also cited the lack of government incentives as contributing to the slow uptake of solar technology.[195] This lack of more "active" policy support for solar power (and indeed most other renewable sources) continues to hinder renewable development, an issue that is expanded on in the conclusion to this part below.

7.4 Conclusion — Can Renewables Actually Meet their Potential?

New Zealand has an enviable portfolio of renewable generation resources, but political barriers may prevent it from capitalising on this endowment. A worrying pattern has emerged, where renewable operators are required to undergo a long and expensive regulatory approval process. The operator may gain approval — but could still end up shelving the project for economic and public relations reasons. This pattern calls into question whether New Zealand can meet its target of 90 per cent renewable electricity generation by 2025.

In addition, New Zealand lacks more "active" policies to incentivise investment in renewable projects. Additional support mechanisms could include economic measures such as a feed-in tariff system. With the feed-in tariff mechanism, legislation compels electricity distributors to accept electricity from renewable generators, in preference to non-renewable sources. The system guarantees the renewable electricity operator a fixed rate or "tariff" for its output.[196] The specified tariff will cover the difference in costs between renewable generation and more conventional methods, thus incentivising investment in the renewable source.[197] If New Zealand's Government is serious about its commitment to renewable electricity, it may need to adopt similar "active" policy instruments.[198]

194 *Assessment of the Future Costs and Performance of Solar Photovoltaic Technologies in New Zealand* (IT Power Australia Pty Ltd and Southern Perspectives Ltd, April 2009) at 61–63.

195 At 64–65.

196 David Grinlinton and LeRoy Paddock "The Role of Feed-in Tariffs in Supporting the Expansion of Solar Energy Production" (2010) 41 University of Toledo Law Review 943 at 943 and 944.

197 At 946.

198 Kelly, above n 146, at 2504.

8. "GOING NUCLEAR" — IS THIS A BETTER OPTION?

> *More dams? Rejected because of environmental impacts. Wind farms? Okay for some, but hardly an option for feeding the national grid, marginal at best. Greater reliance on gas, coal and oil? Environmental issues again as well as the high costs of developing gas fields … Then there's nuclear — oh wash your mouth out. Globally as important a source as hydro, it supplies 80 per cent of France's power needs, 35 per cent in Germany, 25 per cent in the UK and 20 per cent in the US. And wait, there's more — no CO_2 emissions, and lower cost. The contribution a nuclear power plant or two could make here is enormous.*
>
> — Gareth Morgan[199]

I have discussed New Zealand's energy challenges: to obtain a secure electricity supply and to accomplish this security in a way that minimises greenhouse gas emissions. In this part of the article, I now assess the "radioactive question" — that is, should New Zealand seriously consider using nuclear energy to address these challenges?

8.1 Reason to Embrace the Atom …

8.1.1 Nuclear power could provide energy security for New Zealand

Four factors affect secure electricity supplies in New Zealand, according to MfE. First, New Zealand relies heavily on hydroelectric assets.[200] This leaves New Zealand open to power shortages in dry periods, as occurred in 1992, 2001, 2003 and 2008.[201] Secondly, most of New Zealand's large hydroelectric plants are far from population centres,[202] so New Zealand needs transmission infrastructure that can distribute electricity to consumers without significant losses.[203] Thirdly, New Zealand cannot import electricity, so electricity markets can be volatile. Finally, electricity generation assets must be large enough to be economic — but New Zealand's small size means that these assets will be

199 Gareth Morgan "Fallout from war hurts us" *Waikato Times* (New Zealand, 12 April 2003) at 23.
200 NZES 2050, above n 111, at 61.
201 Johnson, above n 159, at 208.
202 NZES 2050, above n 111, at 61.
203 Johnson, above n 159, at 202–203.

large relative to the market.[204] Therefore, there needs to be substantial back-up infrastructure to make up for periods when these assets go offline.

Nuclear energy could address some of these issues. In 2003, for example, dry conditions depleted hydro lakes, resulting in a fivefold increase in wholesale electricity prices.[205] Nuclear power would not be as susceptible to changing weather conditions.

Historically, fossil fuels have provided the "security and versatility" to ensure stable electricity supplies.[206] In particular, indigenous gas from the Maui field has stepped into the breach when hydroelectric resources cannot meet demand.[207] However, the Maui gas field is unlikely to be able to maintain traditional rates of supply in the long term,[208] although recent estimates indicate that recoverable gas reserves are greater than previously thought.[209] Accordingly, relying on gas to make up for hydro shortfalls is unlikely to provide energy security into the future.[210]

Nuclear energy is potentially unique in that nuclear power plants can provide reliable base-load generation without emitting greenhouse gases.[211] As a consequence, nuclear power could ostensibly replace fossil fuels as a method of generating consistent base-load electricity.[212]

Furthermore, NZES 2050 highlights that New Zealand's reliance on imported oil leaves the country susceptible to international events beyond its control.[213] Arguably, investing in nuclear energy could lessen this reliance. Uranium occurs naturally across five continents, so there is less chance that a uranium-producing country or region will gain a monopoly over the resource.[214] In addition, uranium has a high energy density, meaning that nuclear power plants need relatively small amounts of fuel.[215] Uranium shipments are also

204 NZES 2050, above n 111, at 61.

205 Barry Barton "Law, Government and State: Trends in Energy Law" (2004) 7 Yearbook of New Zealand Jurisprudence 1 at 3.

206 NZES 2050, above n 111, at 62 and 64.

207 Johnson, above n 159, at 208.

208 At 209.

209 *Energy in New Zealand 2014*, above n 138, at 27; Ministry of Business, Innovation and Employment "Latest energy statistics published" (31 July 2014) <www.mbie.govt.nz>.

210 Johnson, above n 159, at 224.

211 Debra Carfora "Building a Sustainable Energy Future: Offering a Solution to the Nuclear Waste Disposal Problem through Reprocessing and the Rebirth of Yucca Mountain" (2012–2013) 8 Tex J Oil & Gas Energy L 143 at 144.

212 Ralph Sims, Hans-Holger Rogner and Ken Gregory "Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy resources for electricity generation" (2003) 31 Energy Policy 1315 at 1316.

213 NZES 2050, above n 111, at 12.

214 *Climate Change and Nuclear Power 2014* (International Atomic Energy Agency, 2014) at 29.

215 At 29–31.

less reliant on fixed shipping routes or pipelines, reducing the potential for interruptions to supply.[216] Uranium could therefore be more reliable as a fuel source.

Furthermore, nuclear power compares favourably in some cost assessments. A 2003 study estimates that new nuclear plants could incur generating costs in a range of 3.9 to 8 US cents per KWh.[217] New reactor designs could reduce this to 2 US cents per KWh — although the study concedes that this projection may be a result of "engineering optimism".[218] To compare, this study assesses hydro costs at 6 to 12 US cents per KWh and wind costs at 3 to 5 US cents per KWh (in high-wind areas — the cost increases to between 10 and 12 US cents per KWh in areas with poorer wind resources).[219] Admittedly, this study does concede that nuclear power plants will probably not be a least-cost alternative in most countries. There are exceptions, though — that is, countries that have limited indigenous fossil resources or where there are large distances between electricity generation sources and demand centres.[220] New Zealand fits this bill. A nuclear power station could be located close to New Zealand's population centres, reducing the costs and electricity losses associated with long-distance transmission.

8.1.2 Nuclear power could mitigate New Zealand's contribution to climate change

Nuclear power could offer a means to curb global warming.[221] Nuclear plants do not produce greenhouse gas emissions when they operate. The processes of uranium mining, refinement and transport, along with plant construction, will generate emissions,[222] but the same is true of renewable assets. On some estimates, the "life-cycle emissions" of nuclear power are comparable to many renewable generation sources.[223] The IAEA has calculated life-cycle emissions for various energy sources. On these estimates, nuclear comes in at second only to hydro.[224] Nuclear energy, it would seem, offers a definite improvement over fossil generation (and many renewable sources) in this respect.

The amount of emissions that nuclear energy avoids each year also demonstrates its ability to combat climate change. The IAEA estimates that

216 At 31.
217 Sims, Rogner and Gregory, above n 212, at 1317.
218 At 1318.
219 At 1318.
220 At 1318.
221 *Nuclear Power in a Warming World: Assessing the Risks, Addressing the Challenges* (Union of Concerned Scientists, December 2007) at 2.
222 At 11.
223 At 11.
224 *Climate Change and Nuclear Power 2014*, above n 214, at 16.

nuclear energy avoided 2.1 gigatonnes of CO_2 emissions in 2011.[225] This assumes that if the nuclear resource had not been available, fossil fuels would have generated the same electricity.[226] Although this may be a simplistic assessment, it does suggest that nuclear power could contribute to the decarbonisation of the global economy.

8.2 … and Reasons to Stick with What We Know

8.2.1 Nuclear energy is too large-scale for New Zealand

New Zealand's small population is unlikely to create enough electricity demand to make a nuclear reactor economically viable. Even a single reactor would dominate New Zealand's electricity generation system, leading to problems if that plant had to go offline for any reason. Admittedly, the development of "Small Modular Reactors", which are simpler and produce less electricity, could change this evaluation in future.[227] For the time being, though, nuclear looks set to remain large-scale.

Nuclear power plants are ill-suited to adjust to fluctuations in electricity demand. It is rare for nuclear reactors to "load-follow" — that is, to adjust their output to match rising or falling demand. Instead, reactors operate at peak capacity to provide base-load electricity. Not only is this the most economical way to run nuclear reactors, it is also the safest. Fluctuations in output can raise the potential for sudden power surges, which can damage the nuclear fuel and increase the risk of a meltdown.[228]

As a consequence, reactors should operate at essentially full capacity, at all times. This mode of generation may not be appropriate in the New Zealand context. Commercial nuclear plants typically have approximately 1,000 MW in generating capacity.[229] Even the smallest realistic commercial plant would still have a capacity of about 550 MW.[230] New Zealand only needs around 4,500 MW of capacity to meet electricity demand at any given time.[231] Accordingly, a nuclear plant would supply around 22 per cent of the country's electricity demand.

If New Zealand went nuclear, it would likely result in an energy mix dominated by nuclear and hydroelectricity. As discussed, nuclear would have to consistently provide around 22 per cent of electricity output. Hydro, along

225 At 18.
226 At 18.
227 *Small Modular Reactors: A UK Opportunity* (Institution of Mechanical Engineers, September 2014).
228 *Nuclear Power in a Warming World*, above n 221, at 50–51.
229 Johnson, above n 159, at 225; *Future Currents*, above n 97, at 84.
230 *Future Currents*, above n 97, at 84.
231 Johnson, above n 159, at 225.

with other sources, would then supply the rest. This is not compatible with the Government's target for 90 per cent renewable electricity generation by 2025. If nuclear power supplied a fifth of New Zealand's electricity, renewable sources could comfortably make up the rest — but would be relegated to supplying only around 78 per cent of New Zealand's demand. Nuclear power would therefore require the Government to change its existing energy policies.

A single reactor, supplying 22 per cent of electricity demand, would also require New Zealand to maintain considerable reserve capacity to deal with planned and unplanned outages. Such outages would have to occur every one to two years, when the operator must shut the plant down to refuel.[232] A nuclear power plant could therefore be incompatible with New Zealand's electricity system, given the relatively small size of the market.

Furthermore, an electricity system dominated by nuclear and hydro would leave New Zealand particularly vulnerable to shortages if a nuclear outage happened to coincide with a particularly dry year. This vulnerability would undermine the Government's energy security goal. New Zealand would need to maintain further reserve capacity to avoid electricity shortages if a nuclear outage occurred at the same time as a shortfall in hydro capacity. Maintaining this reserve capacity would be expensive. It could also impede the goal of addressing climate change, because New Zealand would presumably have to retain considerable thermal capacity to make up for any shortfalls.

Nuclear energy tends to only be cost-efficient in countries with large, dense populations whose electricity use can support the economies of scale necessary to make nuclear power viable.[233] The Royal Commission affirmed in 1978 that nuclear energy would be necessary moving into the 21st century — on the assumption that New Zealand would consume 68,000 GWh of electricity annually by the year 2000.[234] The Commission broke this down as follows.

Table 8: Year 2000 electricity demand by sector — Royal Commission projection[235]

Sector	**Annual electricity demand (GWh)**
Domestic	26,000
Industrial	28,000
Commercial	11,000
Transport	3,000
Total	68,000

232 *Future Currents*, above n 97, at 84.

233 Adrian Bradbrook "Sustainable Energy Law: the Past and Future" (2012) 30 JENR 511 at 516.

234 Royal Commission, above n 15, at 43.

235 At 43.

The Commission acknowledged that the accuracy of this projection would depend on population and gross domestic product continuing to grow as predicted.[236] Oddly enough, the Commission did not consider that conservation techniques would be likely to succeed unless they were able to "demonstrate a well-defined economic advantage".[237] Consider the Royal Commission's analysis in light of the actual statistics for the year 2000.

Table 9: Year 2000 electricity demand by sector — actual[238]

Sector	**Annual electricity demand (GWh)**
Agriculture, forestry and fishing	1,296
Industrial	14,390
Commercial (including transport)	6,913
Residential	11,261
Other	756
Total	34,616

The Royal Commission's estimates were well off the mark. The Royal Commission projected that New Zealand would use almost exactly double the amount of electricity that it actually consumed in the year 2000. Energy efficiency continues to improve, dampening growth in demand,[239] which may explain why the actual statistics for the year 2000 were so much lower than anticipated. This also suggests that the projections assessed in part 6 of this article could overstate how much electricity New Zealand is going to need in the future. There may well be a continued "organic" improvement in energy efficiency that will reduce future rates of growth in demand.

Uncertainty about future electricity demand in New Zealand is further compounded by the potential closure of the Tiwai Point aluminium smelter. This operation makes up approximately 13 per cent of New Zealand's electricity demand,[240] so there is scope for a considerable slump in the near future if the smelter closes. The much slower actual growth in electricity demand — and the

236 At 43.
237 At 44.
238 *Data tables for electricity* (Ministry of Business, Innovation and Employment, 19 April 2015) <http://www.med.govt.nz/sectors-industries/energy/energy-modelling/data/electricity>.
239 Johnson, above n 159, at 223.
240 *New Zealand's Energy Outlook*, above n 126, at 5.

possible reduction if Tiwai closes — suggests that New Zealand may not yet need to turn to nuclear energy to meet its electricity needs.

8.2.2 Nuclear fuel supplies may be hard to guarantee in the future

The OECD's Nuclear Energy Agency (NEA) and IAEA assess the world's known recoverable uranium reserves, able to be recovered at less than US$130 per kilogram, at 5,902,900 tonnes.[241] In 2012 the world's nuclear reactors used 61,600 tonnes of uranium each year to produce 371,961 MW of electricity.[242] The NEA and IAEA forecast that the world's existing assessed uranium resources can meet this level of demand for another 120 years.[243] However, they also project that global nuclear generation capacity is likely to expand, with subsequent increases in demand for uranium. Table 10 summarises the OECD and NEA's "low case" and "high case" projections to 2035.

Table 10: Increases in global nuclear generation capacity and demand for uranium to 2035[244]

Year	**Generation capacity (MW)**		**Uranium demand (tonnes)**	
Actual				
2012	371,961		61,600	
Projected				
	Low case	High case	Low case	High case
2020	394,100	462,415	66,200	78,335
2030	432,691	650,455	77,815	117,990
2035	399,143	678,486	72,205	122,110

As Table 10 shows, increases in demand for uranium could total anything from 20 per cent (in the low case) to 105 per cent (in the high case).[245] Worldwide, 66 reactors are under construction. A further 168 are planned, with 322 proposed.[246]

241 *Uranium 2014: Resources, Production and Demand* (OECD Nuclear Energy Agency and International Atomic Energy Agency, 2014) Table 1.2 at 20.
242 At 77 and Table 1 at 103.
243 At 130.
244 Adapted from *Uranium 2014: Resources, Production and Demand*, above n 241, Tables 2.3 and 2.4 at 102–105.
245 At 101.
246 World Nuclear Association "World Nuclear Power Reactors & Uranium Requirements"

This future profusion of reactors will place significant pressure on uranium resources.[247]

Additionally, if New Zealand adopted nuclear energy, it would expose the country to fluctuations in uranium prices. The cost of uranium has been volatile — ranging from approximately US$7 per pound in the 1980s and 1990s to as high as US$138 per pound in the early 2000s.[248]

In consequence, if New Zealand does choose to invest in nuclear energy, it will have to procure uranium from global markets that will become increasingly competitive. The projected increases in demand cast uncertainty over how long existing resources are likely to last. Prices may also become more volatile. In saying this, the WNA insists that higher uranium prices and increased exploration will make more uranium available in the future.[249] The IAEA and NEA also affirm that currently assessed resources will be enough to meet even high-case demand through to 2035.[250] If uranium prices do increase in response to demand, it may not be economic in the long term for New Zealand to invest in nuclear energy. Nuclear power therefore may not provide the energy security New Zealand is seeking.

8.2.3 Using nuclear power carries a number of safety risks

(i) Reactor accidents

To date, four accidents have been large enough to shut the affected reactor down and release radioactive material beyond the plant site. These accidents occurred at Windscale (United Kingdom) in 1957, Three Mile Island (USA) in 1979, Chernobyl (USSR) in 1986, and Fukushima (Japan) in 2011.[251] The accidents demonstrate that even civilian applications of nuclear technology can potentially have an enormous impact on human health and the environment.[252]

Nuclear systems have become safer in recent years.[253] But nuclear power systems are still vulnerable to external factors such as human error and natural disasters. These external factors played a significant role in the four accidents

<www.world-nuclear.org>. "Planned" refers to reactors with approvals or funding in place. "Proposed" refers to reactors for which there is a specific programme or site proposal.

247 Carfora, above n 211, at 171.

248 Toni Johnson "Global Uranium Supply and Demand" (January 2010) Council on Foreign Relations <www.cfr.org>.

249 World Nuclear Association "Supply of Uranium" (October 2014) <www.world-nuclear.org>.

250 *Uranium 2014: Resources, Production and Demand*, above n 241, at 130–131.

251 McEwan, above n 6, at 50. I have added the Fukushima accident to McEwan's list.

252 Elena Moldodstova "Nuclear Energy and Environmental Protection: Responses of International Law" (1994) 12(1) Pace Environmental Law Review 185 at 188.

253 NZES 2050, above n 111, at 19.

listed above.[254] As an illustration, a committee appointed by the Japanese Diet (parliament) to investigate the Fukushima accident concluded that the disaster was as much "man-made" as natural — the result of "collusion" between government, regulatory bodies and the plant's operator.[255] The Diet's committee judged that regulators and operators prioritised their own interests over the public's safety.[256]

(ii) Nuclear terrorism

Terrorism is a further cause for concern. Terrorist groups could deliberately sabotage a nuclear facility, leading to an uncontrolled release of radiation.[257] Alternatively, these groups could acquire nuclear material from a reactor facility and use this to create a weapon.[258] New Zealand would need to be conscious of these factors. Canada, for example, enacted the Nuclear Terrorism Act SC 2013 c 13 (NTA) to address nuclear terrorism. The NTA created new offences, including the use of a nuclear device to cause death or substantial damage, or attacking a nuclear facility.[259] Although New Zealand does not have large-scale nuclear facilities, the Terrorism Suppression Act 2002 contains similar offences to the Canadian legislation, including:

- unlawful handling of or dealing with nuclear material;[260]
- importing or acquiring radioactive material with intent to commit an offence;[261] and
- making or possessing radioactive material and devices with intent to cause damage to people or property (or threatening to do so).[262]

In consequence, New Zealand actually does have the legislation to deal with nuclear terrorism. Practically, however, it would need to develop the capacity to enforce these provisions. Additionally, a stringent security framework for sites handling radioactive materials would be necessary.[263]

254 See McEwan, above n 6, at 56–58 and Kiyoshi Kurokawa and others *The Official Report of the Fukushima Nuclear Accident Independent Investigation Commission* (The National Diet of Japan, 2012).
255 Kurokawa and others, above n 254, at 16.
256 At 43.
257 *Nuclear Power in a Warming World*, above n 221, at 31.
258 At 37.
259 Nuclear Terrorism Act SC 2013 c 13, s 5.
260 Terrorism Suppression Act 2002, s 13C.
261 Section 13D.
262 Section 13E.
263 *Nuclear Power in a Warming World*, above n 221, at 37.

(iii) Additional costs of minimising risks
Steps to minimise nuclear risks could also make nuclear power less economically viable. After Fukushima, a number of countries began reviewing the safety of their nuclear power assets.[264] Regulators are likely to issue new safety requirements. These more stringent safety requirements will increase costs for nuclear operators. If costs increase to a point where nuclear power is no longer economic, operators may close plants or not renew licences.[265] New Zealand would undoubtedly require high safety standards for nuclear power plants. Needless to say, high safety standards are desirable — but they would increase the costs of producing nuclear power.

(iv) Conclusions on nuclear risks
New Zealand would not be immune to natural and man-made safety concerns. In its comments on safety, the Royal Commission stated: "There is no such concept as absolute safety, there is always risk."[266] Granted, all electricity sources carry risk. Societies must come to their own conclusions about what level of risk and environmental damage (actual or potential) they are willing to tolerate.

If New Zealand embarks on a nuclear power programme, it will have to accept the risk, however remote, that a nuclear reactor accident could occur. If a large-scale accident ever occurred, New Zealand would have to deal with environmental consequences and also large-scale social issues such as population displacement, disruption to families and communities, and mental health concerns.[267] New Zealand would need stringent regulations to minimise this risk as much as possible — which would make nuclear energy less economically viable. New Zealand is well endowed with alternative potential electricity sources. Given the high impact of a reactor accident and the ready availability of alternatives, running the risk of a nuclear accident is arguably not justified.

8.2.4 Radioactive waste is a further problem

A 1,000 MW station uses around 200 tonnes of natural uranium annually as fuel.[268] After 18 months to three years, the nuclear fuel must be removed from the reactor and replaced.[269] A nuclear power reactor will generally produce three types of waste. The first is high-level waste (HLW). Reactors produce

264 Joskow and Parsons, above n 3, at 14–18.
265 At 18–19 and 25–26.
266 Royal Commission, above n 15, at 104.
267 Kurokawa and others, above n 254, at 19 and 30–40.
268 Royal Commission, above n 15, at 83.
269 Carfora, above n 211, at 148.

comparatively small volumes of HLW, but it is intensively radioactive. Reactors will also produce transuranic or intermediate-level waste. This type of waste is less radioactive than HLW, but it is produced in greater volumes and must also be isolated. Finally, there is low-level waste, which is radioactive but can be disposed of just below ground level.[270]

The product of a reaction in a 1,000 MW nuclear power station will be around 300 m^3 of low- and intermediate-level waste and 30 tonnes of HLW each year.[271] Radioactive waste remains dangerous to people and the environment for thousands of years.[272] Dealing with radioactive waste is therefore intergenerational: future generations must sustain any waste management strategies implemented in the present.

The first step in disposal is for the used fuel rods to be submersed in cooling pools for five to seven years.[273] After this point, the waste can be stored at the reactor site itself. However, this is not a long-term solution. At present, the best available method of long-term disposal appears to be permanent storage in deep, stable geological formations.[274]

Canada passed the Nuclear Fuel Waste Act SC 2002 c 23 (NFWA) in 2002. The NFWA established the Nuclear Waste Management Organization (NWMO).[275] The NWMO had three years to evaluate potential approaches to waste management.[276] Based on this evaluation, the NWMO had to recommend a solution to Canada's Minister of Natural Resources.[277] Its options were:[278]

- deep geological disposal;
- storage at reactor sites; or
- centralised storage, either above or below ground.

In 2005 the NWMO recommended an "adaptive phased management" approach.[279] This approach will consist of a three-step process. In the first two steps (lasting approximately 60 years), fuel is to be stored at reactor sites before being transported to an optional shallow underground central storage site. Beyond 60 years, the fuel is to be stored at a central deep-storage facility.[280]

270 *Nuclear Power in a Warming World*, above n 221, at 183.
271 McEwan, above n 6, at 202.
272 Carfora, above n 211, at 148.
273 At 148.
274 *Nuclear Power in a Warming World*, above n 221, at 7.
275 Nuclear Fuel Waste Act SC 2002 c 23, s 6.
276 Section 12(1)(a).
277 Section 12(1)(b).
278 Section 12(2).
279 *Choosing a Way Forward: The Future Management of Canada's Used Nuclear Fuel — A Summary* (Nuclear Waste Management Organization, 2005) at 4.
280 At 4–5.

Waste disposal was a major caveat in the Royal Commission's report. The Commission considered that nuclear power would be unacceptable if a feasible waste disposal plan could not be established. The Commission stated that this would be difficult unless New Zealand could persuade a foreign country with suitable geological sites (such as Australia) to accept New Zealand's waste.[281]

The IAEA's position on the matter is that a country that utilises nuclear energy for its benefit should take full responsibility for managing the resulting radioactive waste.[282] Fortunately for New Zealand, the IAEA concedes that international collaboration may still constitute responsible waste management.[283] Accordingly, an export regime could be possible — provided New Zealand can find a willing recipient.

Regardless, nuclear fuel waste remains an issue. The best available solution at present is storage in deep, stable geological formations. These are not in abundant supply in New Zealand. The long time periods involved mean that future generations would have to maintain any safeguards put in place at the time the waste was created. Until a more satisfactory method to dispose of radioactive waste emerges, this issue remains a significant factor against investing in nuclear energy.

8.2.5 Energy efficiency may be a better solution

To close this analysis, it is acknowledged that the article has assessed solutions to New Zealand's energy concerns on the basis that energy use trends will continue as they have in the past. The trend assumes that demand for electricity will increase at a steady rate over time. Implicitly, this defines the problem as one of calculating how to maintain energy-rich lifestyles in a world where the economic and environmental costs of fossil fuels are no longer sustainable.

This does not have to be the case. A fundamental shift in how consumers use electricity — that is, to address "demand-side issues" — could go a long way to meeting New Zealand's (and indeed the world's) energy challenges. Energy security is not a case of managing electricity supply alone.[284] By effectively identifying and addressing inefficient energy use, New Zealand can substantially reduce demand for electricity.[285] In some estimates, improved energy efficiency could potentially contribute more towards stabilising carbon

281 Royal Commission, above n 15, at 187.

282 *Developing multinational radioactive waste repositories: Infrastructural framework and scenarios of cooperation* (International Atomic Energy Agency, October 2004) at 1.

283 At 1.

284 Johnson, above n 159, at 231.

285 At 231.

emissions than all other sources, including nuclear.[286] New Zealand should therefore not overlook the relevance of demand-side measures as it seeks to ensure energy security while protecting the environment.

9. CONCLUSION

This article has established that, superficially, nuclear energy offers an ideal solution to many of New Zealand's energy concerns. It is not susceptible to many of the problems that plague New Zealand's existing electricity system. Dominated by hydroelectric resources that are remote from major demand centres, New Zealand's national grid suffers from high transmission costs and remains vulnerable in dry years. Nuclear plants, on the other hand, can be located close to population centres. These plants can provide electricity without the same fluctuations that affect renewable sources, or the greenhouse gas emissions that fossil fuels produce. New Zealand has seriously considered nuclear electricity generation in the past. To this day, the country does not legally prohibit nuclear power. New Zealand should not exclude the nuclear option from the energy debate altogether.

On closer analysis, however, nuclear energy begins to lose its allure. Practically, the scale that nuclear power operates on is too large for New Zealand. A single nuclear reactor would provide one-fifth of the country's electricity — a situation that could cause havoc if that plant suffered an outage. New Zealand arguably lacks a large or dense enough population to provide the necessary economies of scale to make a nuclear plant viable. Using nuclear energy raises many valid safety concerns. These include reactor accidents, terrorism, and the ongoing potential for harm from radioactive waste. It is debatable whether an acceptable solution to these issues has yet been found.

Furthermore, this article has shown that New Zealand has more than enough renewable electricity sources to meet its needs. New Zealand is in an enviable position by world standards. With such a diverse renewable portfolio, it does not need to take the risks associated with nuclear power to meet electricity demand. Renewable sources are more than adequate.

This conclusion comes with a caveat. Political barriers and ongoing opposition from interest groups have been allowed to frustrate renewable proposals in recent years. If New Zealand is serious about addressing the dual challenges of energy security and climate change, it must take a firmer stance to promote renewable developments. Theoretical policy affirmation is arguably not enough. Additional support such as feed-in tariffs should be seriously considered. If New Zealand can find the political will to fully capitalise on its

286 Bradbrook, above n 233, at 514. See Energy Efficiency and Conservation Act 2000.

renewable potential, it will not need to consider the nuclear option for many years to come. In this article, the question has been considered of whether New Zealand needs to change its position on nuclear energy. The analysis has led to a conclusion that it does not.

As a final thought, it may well be that in searching for alternative ways to meet our energy needs we are asking the wrong question. Perhaps it is lifestyles that need to change, not the power sources that sustain them. Electricity demand cannot continue to grow indefinitely. Renewable capacity is not infinite, and will come at an environmental cost. Nor is nuclear energy a panacea. The questions of why and how we use energy do not figure strongly enough in the debate on how best to meet our energy needs. If the world is to navigate the energy challenges of the future, these questions, too, must be addressed.

> *Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius — and a lot of courage to move in the opposite direction.*
>
> — Ernst Friedrich Schumacher[287]

APPENDIX A: THE ROYAL COMMISSION OF INQUIRY'S SUMMATION

Though our report, and even this overview, takes in a mass of detail, and discusses many aspects and consequences of energy and a nuclear power programme, the reader will be aware that our basic conclusions are few. They can be quite briefly stated:

1. There is no satisfactory case for New Zealand to immediately commit itself to a nuclear power programme. On present evidence it appears to have sufficient indigenous resources to enable it to meet its reasonably projected needs for electricity into the next century.
2. New Zealand should aim to rely on its own resources for electricity as long as it is economically and environmentally sensible to do so, rather than introduce such a sophisticated and changing technology as nuclear power.
3. The development and use of indigenous resources to postpone a decision on nuclear power will call for resolution, for substantial allocations of money and manpower, and for the acceptance of some environmental impacts.
4. However, the chances of New Zealand needing nuclear power for electricity generation early in the next century are real indeed, and a significant

287 Ernst Schumacher "Small is Beautiful" (1973) 37(5) The Radical Humanist 18 at 22.

nuclear programme should then be economically possible, if a similar relationship to that which in the past has existed between economic and electricity growths is maintained.

5. The future ability to meet electricity needs is subject to many uncertainties, mainly those of population and economic growths, those of the possibilities of indigenous resources proving smaller or more difficult to develop than expected, and those of the new forms of generation, alternative to nuclear, failing to prove economic.
6. Nuclear power generation for New Zealand also has its uncertainties and difficulties, especially those of obtaining reactors of a suitable type, reasonably certain fuel supplies, and disposing of the waste products of a fission technology.
7. New Zealand should not embark on a nuclear power programme until suitable arrangements for the disposal of all high-level radioactive wastes from any proposed nuclear stations have been convincingly demonstrated.
8. Apart from the disposal of radioactive wastes and the ascertainment of sites suitably located and of acceptable levels of seismicity, there is no one aspect of the consequences of a nuclear power programme which, taken by itself, would lead us to conclude at this time that nuclear power as a form of electricity generation, if needed, should be rejected.
9. Although some groups within New Zealand believe strongly in the advantages of a low energy "conserver" society (both for its own sake and as a means to avoid introducing nuclear power), we are unconvinced that significant energy savings would thereby result without more changes in life-style than are likely to be acceptable to most New Zealanders.
10. For the reasons outlined above, New Zealand should continue to keep in touch with developments overseas and extend its experience and understanding of nuclear technology. Within New Zealand, in particular, preliminary site investigations should be made, related especially to seismic risk and the ascertaining of areas for high-level waste disposal. There should be an active public education policy to place nuclear energy in the context of the whole energy situation rather than consider it as an isolated technology.
11. Moreover, because change will almost certainly call for alterations to any long-term plan of electricity production, we believe that another major review should be made by at least 1985.[288]

288 Thaddeus McCarthy and others *Royal Commission on Nuclear Power Generation in New Zealand* (Government Printer, April 1978) at 57–58.

APPENDIX B: RESOURCE MANAGEMENT ACT 1991, PART 2

Part 2
Purpose and principles

5 Purpose

(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

(2) In this Act, **sustainable management** means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—

(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

6 Matters of national importance

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:

(a) the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:

(b) the protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:

(c) the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna:

(d) the maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers:

(e) the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga:

(f) the protection of historic heritage from inappropriate subdivision, use, and development:

(g) the protection of protected customary rights.

7 Other matters

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to—

(a) kaitiakitanga:
(aa) the ethic of stewardship:
(b) the efficient use and development of natural and physical resources:
(ba) the efficiency of the end use of energy:
(c) the maintenance and enhancement of amenity values:
(d) intrinsic values of ecosystems:
(e) *[Repealed]*
(f) maintenance and enhancement of the quality of the environment:
(g) any finite characteristics of natural and physical resources:
(h) the protection of the habitat of trout and salmon:
(i) the effects of climate change:
(j) the benefits to be derived from the use and development of renewable energy.

8 Treaty of Waitangi

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).