



Air-conditioning in New Zealand: power and policy

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POLICY ANALYSIS

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ABSTRACT

Policies, codes, standards and voluntary 'green' assessments have exacerbated cooling demand in New Zealand's commercial buildings. Building codes allow designs to use single glazing on the facade, voluntary 'green' criteria are not higher than the legal minimum in the code and inexpensive energy for commercial buildings all contribute to an increasing use of air-conditioning. Legal standards for the energy efficiency of the building envelope of commercial buildings have not significantly changed in over a quarter of a century and, over much of the same time, the cost of electricity (the predominant form of energy in New Zealand used to heat and cool buildings) has decreased for commercial buildings. These factors have led to an increased dependency on air-conditioning in commercial buildings. This increase in energy demand is unnecessary and can be reduced through policies, codes, and standards that reduce solar gain and use mixed-mode ventilation. The reduction in air-conditioning demand will improve energy security and reduce greenhouse gas emissions.

POLICY RELEVANCE

Inaction by successive governments (influenced by industries and lobby groups) has resulted in an energy culture in New Zealand that has moved air-conditioning from being a luxury to a dependency. The presented analysis makes a case for improving building standards to reduce commercial buildings' dependency on air-conditioning. New requirements could reduce energy demand by specifying a maximum energy allowed for cooling and a set of practical measures (e.g. the use of natural ventilation, reduction of solar gain by the use of shading, consideration of orientation, maximum amounts of glazing in facades and higher performance specifications for glazing).

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1. INTRODUCTION

This policy analysis focuses on the energy and climate change-related issues concerning the cooling of commercial buildings in New Zealand (NZ). It is argued that the reduction of cooling loads in these buildings (thereby both improving their energy efficiency and reducing their carbon emissions) has not been adequately addressed in policy. This can be seen in both government policy and government research, the New Zealand Green Building Council (NZGBC) and other organisations.

One result of this is that buildings have unnecessarily high cooling loads. A significant number of tall office developments in the central business district (CBD) of Auckland with nearly 100% single-glazing on their elevations have negligible shading and no concern for solar orientation. In the subtropical climate of Auckland, cooling loads in these building types have been estimated to be greater than heating loads (Byrd 2012).

The NZ climate is becoming warmer, with six of its eight warmest years occurring after 2013 (de Jong 2021). In 2020, the government announced a ‘climate change emergency’ and instructed the Climate Change Commission (2021: 111) to prepare a report entitled *A Low Emissions Future for Aotearoa*, which stated that:

The long-term scenarios show that actions to improve energy efficiency of buildings [...] will be important for meeting the 2050 targets.

Given the challenges that climate change presents, this paper reviews the current form and fabric of commercial buildings with respect to their cooling loads. The adequacy of minimum legal standards as well as voluntary standards is questioned. The shortcomings in the knowledge of the performance of existing buildings in terms of cooling loads are also identified.

For comparison, Auckland (the largest city in NZ) has similar cooling degree-days to parts of Cape Town, South Africa, and has about 50% more cooling degree-days than Hobart, Australia (BizEE n.d.).

The issues are even more pressing as climate change will impact the electricity supply in NZ. Policy on electricity supply is closely connected to policy on electricity demand by buildings. Energy policy needs to be reviewed if reducing the cooling loads of buildings is to be addressed. Although NZ has an enviable low-carbon electricity supply from predominantly (approximately 60%) hydropower, a recent study (Carrivick et al. 2020) concluded that NZ had passed ‘peak hydro’. This means that not only is the operational cost of cooling of concern but also is longer term energy security.

2. MINIMUM STANDARDS

When the Building Code (H1) was first introduced in 1992 (Building Industry Authority 1992), it required ‘Heat gains (including solar radiation) through the building envelope’ (clause H1.3.2 (b)) to be accounted for. The NZ Standard that provides guidance on minimum standards (NZS 4243) became active in 1996. This standard was revised in 2007 (NZS 4243.1), but no change was made to its technical content dealing with the building thermal envelope (Standards New Zealand 2007).

Of the three options in the standard that are permitted for assessing compliance with the code, two consider heat loss only *without* a consideration of cooling, shading or glazing orientation. Furthermore, for glazing covering less than 50% of the wall area, there is ‘no requirement’ for the thermal performance of the glazing. From a thermal point of view, excluding ventilation, a building can be compliant even if it has no glass.

The third method (modelling) allows for the trading of heat gains with heat losses and requires a comparison with a ‘reference’ building that is compliant with the code standards. However, the reference building requires no shading, making compliance simple without fully addressing its cooling load. Indeed, the standard states that thermal modelling ‘does not represent good design or energy efficient design’ (Standards New Zealand 2007: 21).

Therefore, it is not surprising that large buildings could be compliant with the Building Code and yet have walls that are clad in only a single sheet of glass without any form of shading or consideration of orientation. It begs the question: Why have any legislation concerning the energy efficiency of commercial buildings if a single sheet of glass across most of a building's elevations achieves the required standard? It would be difficult to produce a less energy-efficient building for both heating and cooling.

In December 2021, a year after announcing a 'climate emergency' and 25 years since the thermal envelope standards were reviewed, the NZ government introduced the new 'acceptable solutions' for energy efficiency in commercial buildings (MBIE 2021). For heat loss from buildings, the thermal resistance values were increased, but they remain the lowest amongst Organisation for Economic Co-operation and Development (OECD) countries. Cooling was not directly addressed in the calculation method except it was considered that compliance with heat loss would be sufficient to satisfy heat gains:

Requirements to account for heat gains from solar radiation are satisfied by complying with the requirements for thermal resistance.

(MBIE 2021: 11)

Apart from the new thermal standards, the government is also working on a framework to reduce emissions from buildings. At present this is a 'vision' to achieve net zero carbon emissions by 2050 (MBIE 2020: 6). This would be achieved by capping the carbon emissions allowed on the basis of floor area (m²) at the design stage. However, no detailed information is yet available.

A further issue to be considered is whether minimum standards by law necessarily result in minimum standards in practice, or whether expected standards of competence can deliver the minimum criteria. There are several reasons why competency in this area falls short. When responding to the question: How can we overcome the challenges to making all commercial buildings energy efficient, a leading consultant in this field stated: 'Ultimately in NZ this is likely to be market driven' (Beca 2018: 1).

This is echoed by the NZIA (2020: 1), which was concerned about improving minimum standards of energy efficiency:

Any changes to the Building Code may further put pressure on building costs. The compliance process for buildings that are not 'standard' should be kept simple, in order to avoid stifling innovation.

3. GLASS BUILDING CREDITS

Building Codes in NZ are the minimum standard. Rising above the standard is voluntary and something that the NZGBC (an organisation offering voluntary certification of buildings) encourages, especially as the criteria with most credits available in the Green Star rating system are concerned with energy. But this leaves the question of why commercial buildings can achieve an acceptable Green Star rating and still have a building envelope that only meets minimum legal standards of energy efficiency and, therefore, be on the verge of breaking the law in a country with some of the lowest standards of all developed countries (OECD 2017).

There are two main reasons for this. First, the ratings are geared so that the energy criteria need hardly be considered and non-energy-related attributes can be used to compensate for poorer building envelope performance. Second, the energy criteria have been poorly informed giving results that are counterproductive to energy efficiency. These are discussed below.

The first reason is that 'energy credits' comprise 25% of all NZGBC credits. However, approximately two-thirds of energy credits relate to the building envelope. Therefore, the maximum a building envelope performance can contribute to 'green' accreditation is 17% ($0.6 \times 25\%$) of the total accreditation. But historically, few buildings get near this. For example, Byrd & Leardini (2011) found that the average score for 'energy' was approximately 50% of the total credits available. This means that the contribution of the performance of the building envelope to an average Green Star rated building was slightly over 8% ($0.5 \times 17\%$).

The second reason is that the criteria are poorly informed. For example, Cichy (2011) found that there were more credits available for air-conditioned office buildings than for naturally ventilated buildings in the rating system. With daylighting, the marginal increase in illumination of the floor (achieved with higher proportions of glazing) with room depth, was rewarded with an exponential increase in credits, thereby encouraging excessive glazing (Byrd 2012).

The criteria for external views could also encourage over-glazing. Based on the more fenestration, the better the view, the basis of these criteria should be balanced with other research on user satisfaction and views. For example, user-satisfaction surveys by the UK's Building Research Establishment (BRE) (Keighley 1973) found that there was no perceived increase in satisfaction of view with glazing over 30% of the internal elevation.

Additional credits are also given for innovation and two landmark buildings applied for credits for the use of double-skin facades to reduce energy use (Safamanesh & Byrd 2012). While there are many different types of double-skin facade, when applied as an additional skin to a sealed, air-conditioned and unshaded building, their measured performance has been questionable at best (Chan et al. 2009; Roth et al. 2007).

Although double-skin facades are frequently installed and claimed to be a method of reducing cooling, there is little evidence to illustrate their effectiveness. A Lawrence Berkeley National Laboratory (LBNL) report on high-performance building facades stated:

It has been extremely difficult to find any objective data on the performance of actual buildings implementing some of these solutions, particularly double-skin facades. [...] Subjective claims abound in the architectural literature.

(Lee et al. 2002: 7)

The same authors also refer to other findings:

Energy-efficiency is not the foremost benefit of double-skin facades and that such benefit derived may well be small, depending upon circumstances.

(Lee et al. 2002: 19)

A double-skin facade in front of a sealed, highly glazed, air-conditioned building is effectively attempting to mitigate a problem that could have been eliminated or significantly reduced by introducing a smaller proportion of glazing in the first place.

Perhaps the most fundamental historical flaw in the NZGBC rating system has been that there was no requirement to monitor or report in any way on the actual performance of the building. There has been little systematic feedback, which makes it difficult for lessons to be learned by the NZGBC, the building owners or policymakers. However, a voluntary rating tool for existing buildings has become available. Administered by the Green Building Council (NZ), it measures their definition of a 'green building'.

4. MONITORING THE PERFORMANCE OF EXISTING BUILDINGS

In the absence of any feedback on the performance of 'green' buildings, research was carried out to review both the impact of large areas of glazing (Byrd 2012) and the effectiveness of double-skin facades (Safamanesh & Byrd 2012) in two flagship 'green' office buildings in Auckland with 5 and 5.5 Green Star ratings (out of a maximum 6 Stars).

Permission was obtained from the owners to review the energy running costs and monitor the temperatures in and around the double-skin facades. However, the energy consumption was not to be disclosed. In brief, the findings were that the buildings were consuming about twice as much energy compared with a reference building with 50% glazing, that the double-skin facades were increasing the cooling load and that the buildings were in cooling mode most of the year.

The research concluded that the reason for the high energy consumption was due to a significant additional cooling demand. The large proportion of glazing was not only allowing significant direct solar heat gains but also was causing glare and direct sunlight on the occupants. As a result,

the internal blinds were closed most of the time (Onyeizu 2014). This significantly reduced the daylight (and view). As a consequence, the electric lighting was switched on all the time. In turn, the heat from the lights contributed to a higher cooling load. In other words, the daylight and view that gained the building 'green' credits were lost by over-glazing.

The above case studies represent a very small proportion of the commercial building stock. However, they are flagship buildings in the heart of NZ's largest city and carry disproportionate attention due to their anticipated environmental performance. If changes in policy are to be robust and effective, then a larger evidence base is required to understand the performance of a larger sample of commercial buildings in terms of energy use and, in particular, cooling load.

This was the purpose of the Building Energy End-Use Study (BEES) carried out by the Building Research Association of New Zealand (BRANZ) (Amitrano et al. 2014). The BEES started in 2007 and lasted for six years and was by far the largest research project into understanding the energy profile of NZ's non-residential buildings. Its mission statement asserted that:

Understanding how energy and water resources are used in non-residential buildings is key to improving the energy and water efficiency of New Zealand's building stock.

The Introduction states:

New Zealand could reduce the energy demand per new building by 40%, achieved through designing to eliminate cooling and maximising daylight.

(Amitrano et al. 2014: 1)

This percentage appears to be based on modelling and not on data collected from the building sample. The sample indicated that nearly all large buildings use centralised heating, ventilation and air-conditioning (HVAC) systems (Amitrano et al. 2014: 68) and that office towers have the greatest proportion of energy used by HVAC systems (Amitrano et al. 2014: tab. 32). This is an important recognition of the energy used by this building type and, therefore, the importance of targeting policy to reduce cooling demand.

Although the report did identify that it was highly variable, there appear to be no real data on how the energy used for space conditioning is split between heating and cooling. This means that vital evidence for policymaking on energy performance, in particular cooling, is missing. What proportion of the nation's energy goes into cooling these building types? After six years of research into actual building energy use, this question was not fully answered and there was little evidence provided to influence policy to improve the New Zealand Building Code (NZBC) and NZGBC criteria or information for building designers or engineers. Follow-up research would be essential if policy is to be implemented concerning climate change.

The Energy Efficiency and Conservation Authority (EECA) of NZ publish data on the energy use for various sectors, including buildings. However, as the data for heating and cooling are aggregated, they provide little insight for establishing a cooling policy for commercial buildings.

5. ECONOMIC INFLUENCES

Developers of commercial office buildings look to the Property Council New Zealand which keeps data on trends in the quantity and quality of office buildings. The council is also influential in setting the levels of financial return through office leasing or renting by use of its 'office building quality grading mix' (McDonagh 2010: 6).

Offices are graded A-C and 'other', with the first criterion in the technical list being air-conditioning. The more energy consumed per m² by the air-conditioning system, the higher the grade of the offices and, therefore, the greater the potential rentable income (McDonagh 2010). This constitutes a potential inducement for any developer to install a high energy-consuming air-conditioning system.

Unsurprisingly, it was found that grade A offices spent more on energy than grade B, and so on. However, these are historical figures from the period 1990–2008 (McDonagh 2010). As there is no

compulsory disclosure or labelling of energy use in commercial buildings in NZ, little evidence exists after 2008 for the impact that the growing number of highly glazed, air-conditioned buildings have on operational energy costs.

The research into the ‘Electricity Use Trends in New Zealand Offices’ (McDonagh 2010) noted the problems in obtaining accurate data on electricity use for various reasons, such as inconsistency in disclosure and having cost, rather than energy use, data as a proxy for electricity use. This resulted in an apparent anomaly that electricity usage (measured in running costs) was appearing to reduce over the survey period.

One reason for the apparent reduction in energy use was that electricity prices were falling (in real terms) during this period. But this fall was only for commercial buildings in NZ. Beginning in the 1980s and through to the 1990s, NZ privatised its electricity supply industry. The reduction of regulatory constraints allowed tariffs to be restructured. This resulted in domestic electricity prices increasing by 74% (in real terms) over almost two decades, but commercial buildings’ electricity prices decreased by 24% (Bertram 2015). The gap is such that the price of electricity for residential buildings is effectively subsidising the price of electricity for commercial buildings, and some of that is for cooling.

While the price of electricity for air-conditioning commercial buildings in NZ has been decreasing since the privatisation of the electricity industry, it begins to explain why there has been no incentive for regulatory change in energy efficiency standards. After all, why increase the energy efficiency of a building when the price of energy is reducing? Householders in NZ are struggling for the necessity to keep their houses warm (approximately 25% are in ‘fuel poverty’; Bertram 2015) because they are effectively paying towards the luxury of commercial buildings to keep cool.

6. CHANGING CLIMATE

While the status quo of the economic climate of poor energy efficiency prevails, the meteorological climate is changing in several ways that impact on cooling in NZ.

First, the climate is getting warmer and the National Institute for Water and Atmosphere (NIWA) (2021) has monitored increasing average temperatures in NZ that are consistent with the rest of the world. These steadily increasing temperatures are what prompted the International Energy Agency (IEA) to publish *Is Cooling the Future Of Heating?* (2020), and to state:

cooling demand is growing at more than 3% a year for the next three decades, 8-times faster than demand for heating in the last 30 years.

(IEA 2020: 1)

NZ is likely to be similarly affected.

Second, the majority of energy supplied in NZ is electricity from hydroelectric dams (MBIE 2018). The dams are fed by a combination of rainfall and glacial meltwater in approximately equal amounts (Fitzharris & Hay 1989). The hydro-dams have only about six weeks’ storage capacity, which effectively make glaciers NZ’s ‘batteries’ that can assist through droughts (‘dry years’) (Gholami et al. 2021).

Several research organisations have monitored the glacial volume and reached similar views: the melt rate of glaciers is increasing exponentially, that the meltwater has passed its peak flow and the glaciers are becoming extinct (Carrivick et al. 2020; NIWA 2020). This could leave a significant and growing energy supply gap as this century progresses and certainly within the lifetime of existing commercial buildings that are dependent on cooling.

In 2019, the Minister of Energy & Resources’ response to the Climate Change Commission (Woods 2019) concerned itself only with ‘dry years’ when there is inadequate rainfall. Despite other Crown agencies warning of the loss of meltwater, the minister’s report does not mention the potential loss of hydrogeneration due to the melting of the glaciers. Nor are the words ‘glacier’ or ‘glacial’ used anywhere in the 417-page report by the Climate Change Commission (2021).

Many of the commercial buildings in NZ are sealed and over-glazed and thus dependent on cooling in order to remain habitable. These buildings may exist after the glaciers have all but gone. The combination of 'dry years' with higher cooling loads is likely to be important characteristics of climate change that will challenge the electricity supply in NZ.

7. CONCLUSIONS

Building energy-efficiency standards have hardly changed for over a quarter of a century in NZ.

Government policy through Building Codes and standards for energy efficiency of buildings and through the Climate Change Commission have focused on heating only.

Existing energy-efficient legislation allows for commercial buildings to be designed without taking account of cooling loads. Few incentives exist in the voluntary 'green' building certification and commercial real estate sector to reduce cooling loads.

The cost of energy to commercial users has historically been reducing (in real terms) since the NZ electricity industry began privatisation. With electricity costs reducing, there is no incentive for commercial building developers to increase energy efficiency standards.

As a result, NZ's commercial buildings are built to some of the lowest thermal standards of developed countries. This is justified by the assumption that the high proportion of renewable energy (in particular hydro) generated in NZ will not deplete over time. However, recent research has demonstrated that the important contribution of meltwater from NZ's glaciers to the hydro-dams has passed its peak and the glaciers are headed towards extinction. It is not just the cost of energy or the impact on climate change that is of concern, but also energy security in the future.

The power cuts that hit Auckland's CBD in 1998 are all but forgotten. The costs, loss of employment, productivity and bankruptcies are believed to be things of the past (Byrd & Matthewman 2013). Unless policy changes are made to reduce energy demand, in particular cooling in NZ, then the 1998 cuts will be seen as a dress rehearsal for the future.

There is an opportunity for NZ to create policy, legislation, standards and competencies to reduce the reliance on air-conditioning in commercial buildings by providing clear energy metrics for cooling, reducing solar gain and encouraging the use of natural ventilation.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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- Amitrano, L. (Ed.), Isaacs, N., Saville-Smith, K., Donn, M., Camilleri, M., Pollard, A., Babylon, M., Bishop, R., Roberti, J., Burrough, L., Au, P., Bint, L., Jowett, J., Hills, A., & Cory, S.** (2014). *Building Energy End-Use Study (BEES) Part 1: Final report* (Study Report No. 297/1). Building Research Association of New Zealand (BRANZ). https://d39d3mj7qio96p.cloudfront.net/media/documents/SR297.1_BEES_Part_1_Final_Report.pdf
- Beca.** (2018). Energy efficiency, what next for commercial buildings? <https://www.beca.com/ignite-your-thinking/ignite-your-thinking/february-2018/energy-efficiency-what-next-for-commercial-buildings>
- Bertram, G.** (2015). *Neoliberalism and energy poverty: Why corporatisation, deregulation and privatisation doubled the cost of electricity for New Zealand households.* <http://www.geoffbertram.com/fileadmin/publications/How%20neoliberalism%20doubled%20the%20price%20of%20electricity.pdf>
- BizEE.** (n.d.). Degree days calculated accurately for locations worldwide. <https://www.degreedays.net/#generate>
- Building Industry Authority.** (1992). *The New Zealand Building Code handbook.* <https://www.building.govt.nz/assets/Uploads/building-code-compliance/handbooks/building-code-handbook/building-code-handbook-1st-edition.pdf>
- Byrd, H.** (2012). Post-occupancy evaluation of green buildings: The measured impact of over-glazing. *Architectural Science Review*, 55(3), 206–212. DOI: <https://doi.org/10.1080/00038628.2012.688017>
- Byrd, H., & Leardini, P.** (2011). Green buildings: Issues for New Zealand. *Procedia Engineering*, 21, 481–488. DOI: <https://doi.org/10.1016/j.proeng.2011.11.2041>
- Byrd, H., & Matthewman, S.** (2013). Renewable energy in New Zealand: The reluctance for resilience. In: *Renewable energy governance: Complexities and challenges* (Lecture Notes in Energy No. 57) (pp. 137–153). Springer. DOI: https://doi.org/10.1007/978-1-4471-5595-9_8
- Carrivick, J. L., James, W. H. M., Grimes, M., Sutherland, J., & Lorrey, A.** (2020). Ice thickness and volume changes across the Southern Alps, New Zealand, from the Little Ice Age to present. *Science Reports*, 10, 13392. DOI: <https://doi.org/10.1038/s41598-020-70276-8>
- Chan, A., Chow, T., Fong, K., & Lin, Z.** (2009). Investigation on energy performance of double skin facade in Hong Kong. *Energy and Buildings*, 41, 1135–1142. DOI: <https://doi.org/10.1016/j.enbuild.2009.05.012>
- Cichy, M.** (2011). *Energy efficiency of tall buildings: Practical methodology for integrated design* (PhD thesis, University of Auckland).
- Climate Change Commission.** (2021). *A low emissions future for Aotearoa.* New Zealand Government. <https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/>
- de Jong, E.** (2021). New Zealand records seventh-hottest year, with extreme weather more likely. *The Guardian*, 12 January. <https://www.theguardian.com/world/2021/jan/12/new-zealand-records-seventh-hottest-year-with-extreme-weather-more-likely>
- Fitzharris, J., & Hay, J.** (1989). Glaciers: Can they weather the storm of climate change? In Welch, R. (Ed.), *Proceedings of the 15th New Zealand Geography conference* (pp. 284–291). New Zealand Geographical Society. [https://catalogue.nla.gov.au/Record/1641465?lookfor=author:%22New%20Zealand%20Geography%20Conference%20\(15th%20;%201989%20;%20Dunedin,%20N.Z.\)%22&offset=1&max=1](https://catalogue.nla.gov.au/Record/1641465?lookfor=author:%22New%20Zealand%20Geography%20Conference%20(15th%20;%201989%20;%20Dunedin,%20N.Z.)%22&offset=1&max=1)
- Gholami, M. B., Poletti, S., & Staffell, I.** (2021). Wind, rain, fire and sun: Towards zero carbon electricity for New Zealand. *Energy Policy*, 150, 112109. DOI: <https://doi.org/10.1016/j.enpol.2020.112109>
- IEA.** (2020). *Is cooling the future of heating?* International Energy Agency (IEA). <https://www.iea.org/commentaries/is-cooling-the-future-of-heating>
- Keighley, E. C.** (1973). Visual requirements and reduced fenestration in offices: A study of multiple apertures and window area. *Building Science*, 8(4), 328–331. DOI: [https://doi.org/10.1016/0007-3628\(73\)90017-0](https://doi.org/10.1016/0007-3628(73)90017-0)
- Lee, E., Selkowitz, S., Bazjanac, V., Inkarojrit, V., & Kohler, C.** (2002). *High-performance commercial building façades.* Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley. https://www.researchgate.net/publication/255275025_High-performance_commercial_building_facade. DOI: <https://doi.org/10.2172/1511286>
- MBIE.** (2018). *Energy in New Zealand.* Ministry of Business Innovation and Employment (MBIE), New Zealand Government. <https://www.mbie.govt.nz/assets/d7c93162b8/energy-in-nz-18.pdf>
- MBIE.** (2020). *Transforming operational efficiency; Building for Climate Change Programme.* Ministry of Business Innovation and Employment (MBIE), New Zealand Government. <https://www.mbie.govt.nz/dmsdocument/11793-transforming-operational-efficiency>
- MBIE.** (2021). *H1 energy efficiency, acceptable solution H1/AS2.* Ministry of Business Innovation and Employment (MBIE), New Zealand Government. <https://www.building.govt.nz/assets/Uploads/building-code-compliance/h1-energy-efficiency/asvm/h1-energy-efficiency-as2-1st-edition.pdf>

- McDonagh, J.** (2010). Electricity use trends in New Zealand office buildings, 1990–2008. Paper presented at the 17th ERES Conference, Milan, Italy, June 2010. https://eres.org/eres2010/contents/papers/eres2010_57_Mcdonagh_ELECTRICITY_USE_TREN.pdf
- NIWA.** (2020). *Glaciers continue to melt away*. National Institute for Water and Atmosphere (NIWA). <https://niwa.co.nz/news/glaciers-continue-to-melt-away>
- NIWA.** (2021). *Annual climate summary*. National Institute for Water and Atmosphere (NIWA). <https://niwa.co.nz/climate/summaries/annual-climate-summary-2020>
- NZIA.** (2020). Submission form for the Ministry of Business Innovation and Employment's (MBIE) 'Building for climate change: Transforming operational efficiency and reducing whole-of-life embodied carbon'. New Zealand Institute of Architects (NZIA). https://www.nzia.co.nz/media/5565813/2020_11-october_climate-change-submission-cover-letterplusattachment_final.pdf
- OECD.** (2017). *Environmental performance reviews: New Zealand*. Organisation for Economic Co-operation and Development (OECD). https://www.oecd.org/env/country-reviews/Highlights_OECD_EPR_NewZealand.pdf
- Onyeizu, E.** (2014). The delusion of green certification: The case of New Zealand green office buildings. In *Proceedings of the 4th New Zealand Built Environment Research Symposium (NZBERS)*, Auckland, New Zealand, 14 November.
- Roth, K., Lawrence, T., & Brodrick, J.** (2007). Double skin facades. *ASHRAE Journal*, October, 70–73.
- Safamanesh, B., & Byrd, H.** (2012). The two sides of a double-skin facade: Built intelligent skin or brand image scam? In *Building on knowledge: Theory and practice, 46th Annual Conference of the Architectural Science Association (ANZAScA)*, Griffith University, Gold Coast, Australia, 14–16 November. <https://anzasca.net/paper/the-two-sides-of-a-double-skin-facade-built-intelligent-skin-or-brand-image-scam/>
- Standards New Zealand.** (2007). *Energy efficiency: Large buildings. Part 1. Building thermal envelope (NZS 4243.1:2007)*. Standards New Zealand. <https://www.standards.govt.nz/shop/nzs-4243-12007>
- Woods, M.** (2019). *Proposed response to Interim Climate Change Committee recommendations on accelerated electrification*. <https://www.mbie.govt.nz/dmsdocument/5963-proposed-response-to-interim-climate-change-committee-recommendations-on-accelerated-electrification-proactiverelase-pdf>

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