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Integrating carbon into Beacon Pathway's Medium Density Housing Assessment Tool

Glenda Lock, Bill Smith, Sally Blackwell and Ian Mayes

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Beacon

BRANZ

1222 Moonshine Rd, RD1, Porirua 5381

Private Bag 50 908, Porirua 5240
New Zealand

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MDH-C/5

Integrating carbon into Beacon Pathway's Medium Density Housing Assessment Tool

Final report

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About This Report

Title

Integrating carbon into Beacon Pathway's Medium Density Housing Assessment Tool - Final Report

Authors

Glenda Lock, Bill Smith, Sally Blackwell and Ian Mayes (Beacon Pathway).

Reviewer

Peter Malcouronne.

Abstract

This report presents the results of Beacon Pathway's work to revise and expand the Medium Density Housing Assessment Tool. We developed an expanded assessment framework for the tool informed by a review of national and international best practice, engagement with previous users of the tool, and our experience applying the existing tool in 15 medium density housing developments. We tested the expanded framework in three case studies and as a result revised a number of elements to produce a final version of the revised tool, which is presented in this report. In conjunction with this, we have developed a simplified, downloadable version to enable developers and other users, to assess their development against the tool's framework themselves. This responds to the educational and behaviour-change opportunities inherent in the tool. Operational and embodied carbon from the construction and operation of MDH are now integral to the tool's core outcomes and its assessment methods.

Reference

Lock, G., Smith, B., Blackwell, S. and Mayes, I. (2024) Integrating carbon into Beacon Pathway's Medium Density Housing Assessment Tool: Final Report. Report MDH-C/5 by Beacon Pathway.

Contents

Notes

- **Greenhouse gas (GHG) emissions / carbon emissions / CO_2 emissions** - Greenhouse gases (GHG) include a range of gases that affect the climate including carbon dioxide, methane and nitrous oxide. As a way of describing different greenhouse gas emissions in a common unit, the term carbon dioxide (CO_2) or carbon dioxide equivalent (CO_2e) emissions is commonly used. In this report we use the shorthand terms of GHG emissions, carbon emissions and CO_2 emissions. This should be read to include all CO_2 equivalent emissions.
- **MDH-1** - Beacon's Medium Density Housing Assessment Tool developed in 2016-2018 and applied up until 2023.
- **MDH-C** – the version of the tool that was tested through this research.

Executive summary

This report outlines Beacon Pathway's work to integrate consideration of operational and embodied carbon emissions from the construction and operation of medium density housing (MDH) into our Medium Density Housing Assessment Tool.

Developed between 2016 and 2018, the original Medium Density Housing Assessment Tool (MDH-1) combined an independent site review, developer interview, and resident survey in a framework that enabled comparison between the perspectives of developers and residents on a range of issues relating to a buildings' design, facilities, access to services, and integration with the community and wider environment.

Since then, the social and political landscape has shifted. Changes in local and central government policy have encouraged more MDH, while the pressure to respond to climate change has intensified. International commitments, as well as national legislative and regulatory changes, underscore the urgency of cutting GHG emissions and adapting to the effects of climate change. Even as the National-Act-New Zealand First coalition government signals a roll back of some important policies and programmes, Aotearoa New Zealand remains bound by its national and international obligations to reduce emissions and the imperative to adapt to the growing impacts of climate change.

These developments provided an opportunity for Beacon Pathway to reimagine its tool. In this project a revised version of the tool (MDH-C) was tested through case studies in the three developments below:

- 26 Aroha - a 13-unit higher-end rental apartment block with a focus on sustainability and community-building.
- A group-home-builder project - a high-end 10-unit medium density housing development, still in the planning stage.
- Oreil Avenue - a 15-unit community housing apartment development with a focus on providing quality, long-term housing.

Key changes to the tool applied through the case studies were:

- Amendment to the tools' underlying framework – these included changes to the core outcomes, their sub-categories and associated questions. The amendments put a greater emphasis on embodied and operational carbon from the design and operation of the development, including residents' behaviour.
- A review of the annual operational CO_2 emissions generated by the development and its residents.

Following the case studies Beacon made final amendments to MDH-C based on feedback from case study developers, insights from applying MDH-C in a Kāinga Ora development, feedback from other stakeholders and our own assessment of what worked well and where improvements were possible.

The final version of the expanded tool is presented in this report. Fundamentally, the revised tool has the same function and underlying assessment approach as its predecessor but with a stronger carbon

imperative. The tool provides a comprehensive framework to assess a development against five core outcomes that encompass current best practice. Using the tool's assessment methods: an independent site review, a developer's interview and a resident's survey, scores are assigned. The tool is unique in bringing residents' voices into an assessment of MDH developments, enabling comparison between what the developer believes they have achieved, with what the residents consider successful.

Alongside this we have developed a simplified, downloadable version of the tool to enable developers, and other users, to assess their development against the tool's framework themselves. The research highlighted the important function of the tool's underlying framework to educate and encourage behaviour change from a range of potential users. The self-assessment version of the tool responds to this need.

MDH continues to play an important role in responding to the pressing need for more affordable, well-performing, homes in Aotearoa New Zealand. Equally, and despite a changing political climate domestically, Aotearoa New Zealand must continue to work towards meeting its international climate change obligations and adapt to the impossible-to-ignore effects of climate change. Beacon Pathway's revised and expanded MDH assessment tool is well-positioned to play a role in enabling MDH developers to respond to these challenges.

2 Introduction

This report outlines Beacon Pathway's work to integrate consideration of operational and embodied carbon emissions from the construction and operation of medium density housing (MDH) into our Medium Density Housing Assessment Tool.

The research responds to a need for practical tools to support MDH developers, and other interested parties, to meet the demand for new housing while also reducing carbon emissions from the construction and operation of MDH developments. Beacon received funding from BRANZ through the Building Research Levy to undertake this work. The research addresses theme two under the 2021 Levy Prospectus Programme: *Reducing greenhouse gas emissions in our building stock now and into the future* by developing and testing a tool to reduce greenhouse gas emissions from existing and new MDH developments.

2.1 Project phases

2.1.1 Discovery phase

The discovery phase ensured that the expanded tool was informed by the current regulatory environment, reflected national and international best practice, and considered the perspectives of key stakeholders. This involved:

- A review of the regulatory and policy environment for low-carbon, quality MDH in Aotearoa New Zealand.
- A review of national and international tools and guidance to:
  - Identify solutions used to reduce GHG emissions in MDH including infrastructure, efficiency and behavioural aspects.
  - Determine effective approaches and those that reflect better practice.
- Engaging with key stakeholders to gather insights to inform the development of the expanded tool.
- Identifying other important issues to consider in developing the new tool, based on the project's goals and findings.

2.1.2 Development phase

This phase focussed on developing MDH-C so that it was ready for testing through three case studies. Work included:

- Reviewing the tool's existing core outcomes to include more specific references to climate change and more proactive climate-oriented actions.
- Expanding the tool's assessment methods to include a review of CO_2 emissions from energy use in public and private spaces.
- Refining the tool's scoring system – including providing clearer guidance for assigning scores and examples of better practice for each of the questions.

2.1.3 Testing phase – case studies

During the testing phase Beacon applied MDH-C in three case study developments: CORT Community Housing's Oreil Avenue apartments, a planned group-home-builder development, and 26 Aroha. During this phase a further assessment was undertaken for Kāinga Ora. While the Kāinga Ora assessment was not within scope of this project, the insights from the assessment informed the finalisation of the tool.

2.1.4 Finalisation phase

Based on the case study results, and follow-up conversations with the developers, MDH-C was finalised. The final outputs include:

- A revised version of Beacon's Medium Density Housing Assessment Tool.
- A free, downloadable self-assessment version for developers to use independently.

Beacon has taken opportunities to share knowledge about the development of MDH-C throughout the project. This includes discussions with stakeholders, updates in Beacon's *Facing* newsletter, and presentations, such as at the Turning Research into Action symposium in Wellington in December 2023.

We're committed to raising the visibility and use of both the self-assessment and full-assessment versions of the Medium Density Housing Assessment Tool. We welcome discussions about our tools and the research behind them. Both the self-assessment version and four public-facing case studies are available on our website.

The following sections outline each project phase, starting with an introduction and background on Beacon's earlier work in developing MDH tools.

3 Background to Beacon's MDH assessment tool

Beacon developed MDH-1 with funding from BRANZ and the Ministry of Business Innovation and Employment (MBIE) in response to BRANZ's 2016 Levy Prospectus Programme 1: *Giving industry the tools to deliver medium density housing that meets the needs of New Zealanders.*

Early work on MDH-1identified five core outcomes crucial to high-quality MDH developments. These outcomes formed the foundation of an assessment framework that allows developers, designers and building managers to compare their own assessment of a development's progress towards these outcomes with residents' perspectives against the same measures. The core outcomes for MDH-1 are summarised below.

Table 1: MDH-1 core outcomes

Character, Context and Identity	To develop a site and buildings that integrate with or relate to existing building form and style in the surrounding neighbourhood.
Choice	The development provides for and enables occupancy by a diverse range of residents that can benefit from and support a thriving local economy with the understanding that high levels of diversity and optimum residential density make the development viable in terms of marketability and cost per unit.
Connectivity	Connecting infrastructure enables safe, universal access using active, mobility, shared and private modes of transport within and through the site to identified key destinations.
Liveability	Providing quality facilities and facilitating positive interactions between residents and the wider community.
Sustainability	Efficient and cost-effective resource use through design, behaviour and technological advancement.

The Beacon report *Medium Density Housing Assessment Tools: Final Report. Report MDH/4* (Ryan, V. and Smith, B., 2018) details the development of the core outcomes and associated assessment framework. As part of the MDH-1 project, the tool was applied in two case studies: Brickworks (Hobsonville Land Company) and Hypatia (Ockham Residential) in Newmarket. The case studies included a site review, developer interview and residents' surveys at each location. The MDH-1 framework, assessment methods and process are summarised in the diagram below.

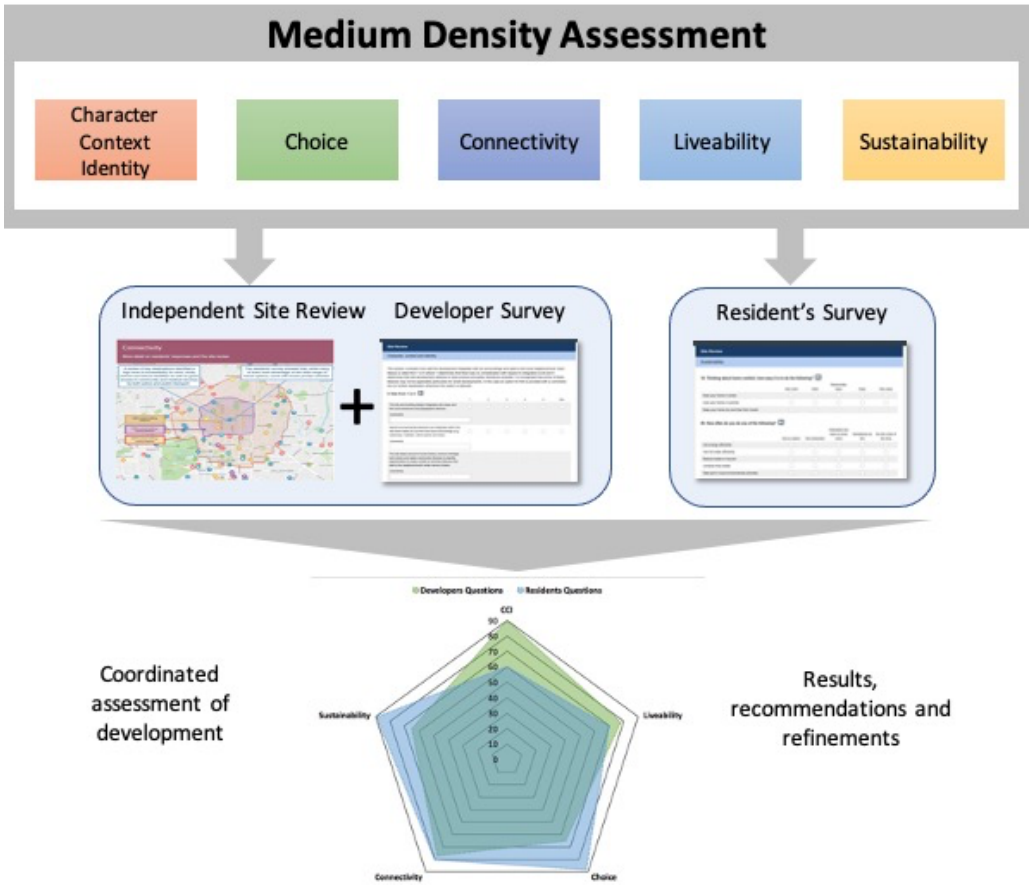


Figure 1: MDH-1 framework, assessment methods and process

This process generated scores from the site review and developer survey, with the developer survey scores compared with residents' scores for specific characteristics under each of the five core outcomes. Developer scores were generally given on a 1-5 scale, where 5 represented alignment with best practice. Residents' scores were inferred, again on a 1-5 scale, with 5 indicating that the outcome or related activity was either very important to the resident or easy for them to achieve.

The residents' and developer's results were then reported to the developers, showing where the residents' perceptions or behaviours differed from the developers' expectations. This led to recommendations that could either be applied to the existing site or inform future designs.

3.1 MDH-1 tool in continuing practice

Since the completion of the initial project, MDH-1 has been applied in 13 further settings, including 11 for CORT Community Housing and two for Christchurch City Council.

Table 2: Developments where the MDH-1 tool has been applied since the completion of the original research project

Name of development	Organisation / Developer	Location	Year of application	Number of residences
Brickworks	Homes Land Community (HLC)	Hobsonville Point, Auckland	2017	60 apartments
Hypatia	Ockham Residential Ltd	Grafton, Auckland	2017	57 apartments
Lynton	CORT Community Housing	Mt Wellington, Auckland	2019	11 units
Mt Wellington	CORT Community Housing	Mt Wellington, Auckland	2019	19 units
Bishop Street	CLR Developments Ltd	Christchurch	2019	6 units
Gloucester Street	Williams Corporation Ltd	Christchurch	2019	15 units
Scott Point	CORT Community Housing	Scott Point, Auckland	2019/2020	13 units
Princes	CORT Community Housing	Ōtāhuhu, Auckland	2019/2020	8 units
Hokonui	CORT Community Housing	Ōtāhuhu, Auckland	2019/2020	12 units
McLennan	CORT Community Housing	Takaanini, Auckland	2019/2020	14 units
Airfield 1	CORT Community Housing	Takaanini, Auckland	2021	19 units
Airfield 11	CORT Community Housing	Takaanini, Auckland	2021	14 units
Glynnbrooke	CORT Community Housing	Te Atatū, Auckland	2021	11 units
Sutton	CORT Community Housing	Papatoetoe, Auckland	2022	27 units
Puhinui Park	CORT Community Housing	Manukau, Auckland	2022	20 units

As the tool has been applied across these sites, we have continued to refine and adapt it to meet developers' requirements and respond to their feedback. Some of the key changes include:

- Adjustments to the survey, such as clearer language, and better alignment between developer and residents' questions (allowing for more comparative responses).
- Introducing additional survey methods (e.g. face-to-face options) to increase tenant engagement and better suit the context where the tool is applied (e.g. community housing, during COVID-19).
- Refining response weightings in the Connectivity section to further encourage active and public transport options.
- Changes to reporting to meet developer needs.

Overall, feedback from developers has been very positive, with MDH-1 becoming a regular part of CORT Community Housing's review process.

4 Discovery phase

Since the development of MDH-1, there has been increasing focus on housing's contribution to GHG emissions and the role residential buildings play in both mitigating and adapting to climate change. This shift has occurred alongside Aotearoa New Zealand's commitment to the Paris Agreement, the declaration of national and regional climate emergencies, legislative changes, and the introduction of strategies and action plans that guide the design, placement, construction and operation of buildings. Taken together, these changes set a clear direction for this project.

During the discovery phase the primary focus was to ensure that the evolution of MDH-1 into MDH-C was informed by the regulatory and policy landscape, as well as insights from national and international best practices, tools and guidance.

4.1 Regulatory and policy context for MDH-C

Beacon undertook a review of Aotearoa New Zealand's regulatory environment for MDH to ensure that the expanded tool reflected, and supported, that context. The review, summarised in Appendix One, identified key legislation, policies and strategies pertaining to MDH and the mitigation of, and adaptation to, climate change, including those relating to:

- Embodied carbon emissions (associated with building materials, construction, transportation, and eventual deconstruction).
- Operational carbon (emissions from energy and water use in building operations).
- Land use planning considerations.

During this project, significant changes to legislation and policy have occurred or been signalled, with further changes anticipated. Despite some uncertainty at the policy level, the key factors that underpin the value of the tool remain constant:

- Medium density housing continues to play a crucial role in Aotearoa New Zealand's housing sector.
- Aotearoa New Zealand has national and international climate change responsibilities, and as such reducing GHG emissions and adapting to climate change are likely to remain important into the future. The housing sector remains an important part of fulfilling these responsibilities.

4.2 Review of other guidance and tools

The development of the MDH-1 framework was informed by a range of existing approaches to reduce environmental impacts, including some that set stringent environmental targets and goals. At that time, the MDH-1 Advisory Group considered that more proactive actions - such as localised energy generation, water harvesting, promoting biodiversity, carbon accounting, offsetting construction activities, and supporting shared and active transport modes – might add too many topics to the wide range developers already had to consider. These measures were also seen as potentially costly, particularly for smaller developers, and could jeopardise their overall engagement with the final tool. As a result, while touching on climate adaptability and solar design, the section on Sustainability in MDH-1 remained somewhat limited in its approach to environmental issues.

In developing MDH-C, we reviewed a range of tools and guidance with a more proactive approach to reducing environmental and climate impacts. The review, summarised in Appendix Two, aimed to identify and determine the following:

- Core principles that lead to reducing GHG emission and impacts on climate.
- Building solutions and occupant behaviours that actively reduce embodied and operational emissions.
- Educational measures that raise awareness about GHG emissions among designers and property managers.
- Assessment methods to monitor operational GHG emissions from heating, cooling, ventilation, lighting, water use and appliances.
- Other approaches that exemplify better practice in assessment, scoring outcomes or offering guidance.

This process identified a range of MDH assessment and guidance approaches that emphasise sustainability and climate change. These include:

- One Planet Living Principles.
- Nightingale Housing.
- LETI Climate Emergency Design Guide.
- Cooperative Research Centre for Low-carbon Living.
- Living Future.
- Passive House.

Alongside these, Aotearoa New Zealand-based guidance and tools included:

- BRANZ MDH and climate change guidance.
- New Zealand Green Building Council's HomeStar and Green Star Communities tools.
- Ngā tohutohu hoahoa ā-motu mō te wharenoho mātoru-waenga – National Medium Density Design Guide.
- Te Aranga Māori Design Principles.
- Kāinga Ora Design Guides.
- Medium – a technical design guide for creating better medium density housing in Aotearoa New Zealand.
- Local government Housing and MDH Guides including the Auckland Design Manual.

5 Development phase

Building on insights from the discovery phase and our experience using MDH-1 across 15 developments, a wide range of issues were identified for consideration as we developed MDH-C. These are summarised below.

5.1 Key issues for consideration

5.1.1 Embodied and operational carbon

While MDH-1 included some sustainability outcomes, its approach was less proactive than some of the guidance and tools we reviewed. MDH-C required a more explicit focus on embodied and operational carbon, therefore attention was given to:

- How the framework and assessment questions align with a rapidly changing operating environment, both in Aotearoa New Zealand and internationally. For instance, the potential future requirements for mandatory embodied and operational carbon assessments.
- How to present highly technical information in a form that accommodates varying levels of understanding – ranging from those with little knowledge (or misinformation) to those with technical expertise.
- How to integrate practical guidance into the tool's framework.

5.1.2 Transport and connectivity

Some of the more ambitious guidance, such as Nightingale Housing and Living Future, consider that carbon emissions from private vehicles can, and should, be reduced through thoughtful design, location and services provided at a development. Examples of best practice in this area include:

- Placing developments near public transport hubs, walkways and cycle paths to improve access to key destinations and reduce car trips.
- Providing secure, well-positioned bike storage and e-bike charging stations.
- Implementing managed vehicle-sharing, including options for e-bikes and scooters.
- Actively managing or reducing the number of car parks to encourage the use of alternative transport modes.

5.1.3 Encouraging residents' interaction and shared resources

Encouraging residents' interaction was a recurring theme in some of the guidance and tools we reviewed. From a design perspective, this could include providing shared spaces like communal laundries, gardens or outdoor cooking areas, with benefits including:

- Fostering social connections between residents, which can improve health, safety and well-being while building trust and encouraging resource-sharing.
- Reducing material use, thereby lowering embodied carbon.
- Freeing up space for other uses, such as shared laundry facilities or centralised solar energy generation and hot water systems. If these facilities aren't already in place, a commissioning process can invite residents to express their interest in such options and explore the conditions that would make resource-sharing more acceptable.

5.1.4 Residents' behaviour and intentions

The behaviour and intentions of residents – such as their approach to water and energy efficiency, recycling, food growing and efforts to reduce their carbon footprint – impact on the operational carbon emissions of a development. Understanding these behaviours can help determine if resources are being used efficiently and allow developers and building managers to assess what might lead to improvements. Regular interactions with residents may also help identify, test and encourage further emissions reductions over time.

5.1.5 Language for the target audience

Beacon's experience with developing and applying MDH-1 along with the review of guidance and tools and conversations with stakeholders all highlighted the need to simplify technical language in the tool to ensure accessibility to the widest possible audience. Aligning terminology used in the tool with terminology used in other key guidance from Aotearoa New Zealand was also raised by stakeholders.

5.1.6 Scoring

Experience with MDH-1 and the review of tools and guidance identified several areas for enhancing MDH-C:

- Better aligning questions for residents and developers, so that their scores are more directly comparable.
- Ensuring the scoring system strikes a balance between assessing outcomes and providing guidance, so that a lower score signals opportunities for improvement without discouraging users.
- Recognising the inherent trade-offs in every development (e.g. balancing privacy and passive surveillance) that make it unrealistic to attain a perfect score.
- Including an option and guidance in the tool for a question to be marked not applicable (e.g. due to the size of the development).

5.1.7 Maintaining engagement

Our experience with MDH-1 showed that the process can be time-consuming, pushing the limits of what some developers and residents are willing to invest. Any revisions for MDH-C should not add to the time commitment. It is also important that topics remain engaging and relevant, as reducing GHG emissions requires developers' on-going engagement and action.

5.2 Shaping a sustainable future: Updates to MDH-1

The issues identified in the previous section provided clear direction for the project's development phase, leading to several revisions to MDH-1.

5.2.1 Adapting the core outcomes

The revisions resulted in a more climate-oriented approach and involved significant changes to the core outcomes and their sub-categories as follows:

- Combining the previous Character Context and Identity and Choice outcomes into an expanded Liveability section.

- Creating a new outcome, Creating Community, which emphasises actions to foster social interaction and incorporates elements from the previous Liveability approach.
- Introducing a new Climate Conscious Design outcome that focuses on reducing embodied carbon emissions.
- Developing a new Sustainable Operation outcome, expanding the previous approach to Sustainability with greater focus on operational carbon emissions.

The changes between the MDH-1 and MDH-C core outcomes are broadly summarised as shown below:

Table 3: Adaptations made to MDH-1 core outcomes in the expanded MDH-C assessment tool.

MDH-1 core outcomes	MDH-C core outcomes
Character Context and Identity	Liveability
Choice	
Liveability	Creating Community
Connectivity	Connectivity
Sustainability	Climate Conscious Design
	Sustainable Operation

The sub-categories for each core outcome were also reviewed and a series of questions developed for each to inform the interviews. They formed the basis for developing comparative questions for the residents (via a survey), site review, and developers (through interviews) to determine how well each outcome had been achieved from different perspectives. Responses were converted into scores, from 1 (lowest) to 5 (highest), for each sub-category. Ultimately, the comparative scores provided the basis for in-depth discussions with the developer actions that could be taken to improve both existing and future MDH projects.

5.2.2 Revised assessment methods

The MDH-1 assessment framework was retained, with the addition of a CO_2 review for testing in three case studies. The framework was applied through:

- An independent site review.
- Developer's interview.
- Residents' survey.
- A CO_2 emissions review.

5.2.2.1 Independent site review

The independent site review involved a desk-based review of documents provided by the developer, followed by a site visit by Beacon Pathway. Depending on the size and complexity of the site, the site review took two to three hours. This visit allowed the reviewer to familiarise themselves with the site, assign initial scores, and identify areas for further discussion in the developer interview.

The site review also included a desktop mapping exercise to score the Connectivity section of the assessment. This evaluated distances and infrastructure connections – such as public transport, walkways and cycling paths – between the development and important amenities like schools, grocery stores, medical centres and leisure facilities.

5.2.2.2 Residents' survey

The residents' survey and scoring approach was designed to mirror the categories and sub-categories assessed in the independent site review and the developer's interview. Surveys were offered face-to-face, hard-copy or online, taking approximately 15-20 minutes to complete.

While the core concepts in the questions remained the same as those posed in the developer's questions, the language was adjusted to be less technical for residents. As with the other approaches, responses were converted into scores, and residents were given the opportunity to comment at the end of each section.

5.2.2.3 Developer's interview

The developer's interview followed the same format as the site review and residents' survey, allowing for easy comparison of results. Interviews last up to two hours and include a discussion of scores from the independent site review.

Developers received the questions in advance, along with notes to help them understand what was required. A 'not applicable' option was included, for limited use where the question does not apply.

5.2.2.4 CO_2 review

A further assessment method was introduced in MDH-C to review the annual operational CO_2 emissions generated by a building and its residents. This was based on an existing methodology, developed with input from the authors of Beacon report *Medium Density Housing Assessment Tools: Final Report. Report MDH/4* (Ryan, V. and Smith, B., 2018) and delivered on behalf of Auckland Council as part of their Multi Unit Dwelling programme. For MDH-C, the CO_2 emissions review was refined to capture data on energy use and calculate CO_2 emissions from lighting, heating, cooling, ventilation and other appliances. The methodology is outlined in Appendix Three.

Operational emissions were calculated by assessing appliances and their usage characteristics during the independent site review. Energy data was collected from both private residences and shared spaces such as stairwells, parking areas and other communal facilities.

The review identified appliances, their wattage and typical usage patterns, including:

- Lighting.
- Security cameras and alarm systems.
- Heaters and hot water systems.
- Ventilation and extraction.

- Cookers.
- Washing machines, dryers, dishwashers and fridges.
- TVs.
- Other relevant appliances.

For public areas, the total numbers of appliances (e.g. lights), were estimated by visually surveying the areas. For private residences, sample of dwellings were reviewed, and the total number of appliances was extrapolated from that. Daily (and annual) usage was either estimated or measured if data was available. Once total kWh were established, this could be factored by coefficients for costs (depending on the fuel type) and CO_2 emissions.

An example of the CO_2 review is shown in the table below, using assumptions for appliances in public spaces and private residences, and a cost of $0.26 per kWh. Emissions are determined at 0.0742 kg CO_2 / kWh for electricity, as determined by the Ministry for the Environment's *Te ine tukunga: He tohutohu pakihi - Measuring emissions: A guide for organisations: 2023 detailed guide.*

Table 4: CO_2 review example

Description / location	Appliance	Type	#/room	# of rooms / floors	Total	Wattage	Estimated annual hrs	KW/h	Cost $	CO_2 kg
Utility rooms										
Bike parking and waste	Lighting	LED	6	1	6	8.5	365	18.615	$4.84	1.38
Connecting stairs and hallways										
Near lift	Lighting - outside	LED	4	3	12	18	365	78.84	$20.50	5.85
Stairway	Lighting - outside	LED	1	1	1	6	1460	8.76	$2.28	0.65
Stairway	Lighting - outside	LED	3	1	3	7.7	1460	33.726	$8.77	2.50
Public toilet										
Toilet / washroom	Lighting	LED	1	1	1	12	365	4.38	$1.14	0.32
Outdoor communal space										
Outdoor rooftop	Lighting - outside	LED	4	1	4	7.7	1460	44.968	$11.69	3.34
Indoor communal space										
Indoor communal / laundry	Lighting - inside	LED	6	1	6	12	1460	105.12	$27.33	7.80
	Appliances - other	Washing machine	3	1	3			919	$238.94	68.19
	Appliances - other	Dryer	3	1	3			462	$120.12	34.28
	Appliances - other	Dishwasher	1	1	1			69	$17.94	5.12
	Appliances - other	Fridge	1	1	1			605	$157.30	44.89
Private residence										
Bedroom	Lighting	LED	2	13	26	8.5	365	80.665	$20.97	5.99
Living and kitchen	Lighting	LED downlight	1	13	13	12	1460	227.76	$59.22	16.90
Hall	Lighting	LED	5	13	65	8.5	365	201.66	$52.43	14.96
Bathroom	Heating / cooling	Towel rail	1	13	13	300	365	1423.5	$370.11	105.62
Living	Heating / cooling	electric fixed	1	13	13	1500	91.5	1784.25	$463.91	132.39
Living	Appliances - Other	TV	1	13	13	100	730	949	$246.74	70.42
Kitchen	Appliances - Other	Cooker	1	13	13	8000	100	10400	$2,704.00	771.68
Kitchen	Appliances - Other	extractor	1	13	13	80	100	104	$27.04	7.72

5.2.3 Self-assessment version

A free self-assessment version of MDH-C that developers could use themselves to assess their plans, or their existing development was developed. This self-guided application was presented as a spreadsheet based on the developer's interview questions. The spreadsheet includes guidance on best practice by way of tangible examples and provides guidance on how to use the tool and assign scores for each outcome area and sub-category.

5.2.4 MDH-C, the tool for testing

Ultimately, the results from the four assessment methods – the independent site review, developer's interview, CO_2 review and residents' survey - were combined to compare scores across the five core outcome areas, as shown below. Brought together, these provided a cohesive framework ready to be tested as the MDH-C tool.

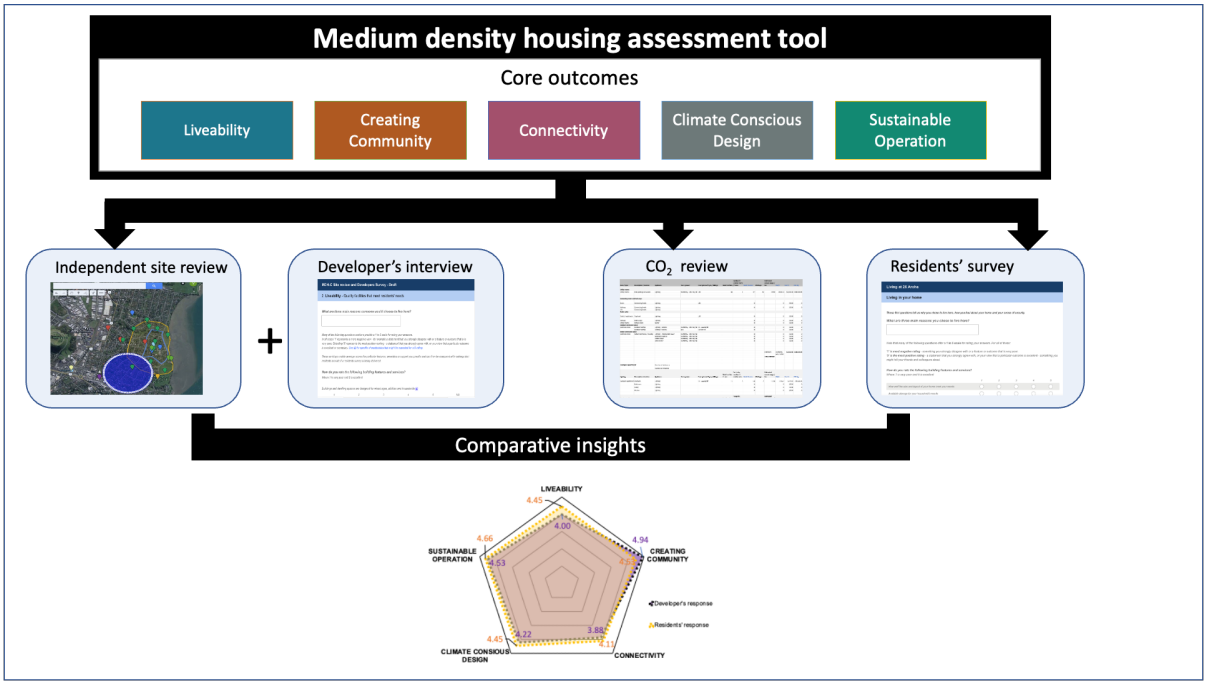


Figure 2: MDH-C assessment methods for testing in case studies

6 Testing Phase: Case Studies

6.1 Case study approach

Beacon used case studies as a method to test MDH-C and, in particular, to understand:

- The value of the tool to encourage and enable developers, and other stakeholder, to plan, design and commission better practice, low-carbon MDH.
- How well the revised core outcomes (and their sub-categories and associated questions) enabled consideration of operational and embodied carbon in the framework. This included understanding whether the core outcomes were comprehensive and well-integrated and that the sub-categories and questions were well-defined, appropriately categorised, clearly worded and without duplication or unnecessary elements.
- The value, applicability and ease of delivery of the desktop CO_2 review.
- The role and value of the proposed self-assessment version including the guidance that would be required for developers, or other users, to apply the tool themselves.
- Whether the framework was applicable in a range of contexts, including in the planning stages, and what modifications, if any, that might require.

6.1.1 Case study selection

Beacon worked with both existing and new stakeholders to identify potential case studies. Three case studies were selected, featuring developers who were not only interested in the project's outcomes but whose developments represented different segments of the MDH market. A summary of these developments is provided in the table below.

Table 5: Case study overview

Development	Research opportunity
26 Aroha High-quality, long-term private rentals.	26 Aroha provided an opportunity to test the tool at a high-quality, community-focused MDH development committed to sustainability and creating community. Both the developer and the residents were highly engaged, keen to learn and wanted to 'do better' where possible.
Oreil Avenue Social housing built and managed by an experienced Community Housing Provider.	Oreil Avenue presented an opportunity to work with a trusted partner interested in the on-going development of the tool and the continuous improvement of their practices, particularly around sustainability and creating community.
Group-home-builder development A planned high-end development to be built for the private market.	This case study provided an opportunity to test the tool's applicability off the plans, identify any implementation challenges, and explore whether early engagement with the developer could lead to improvements before they finalise their plans. It also provided an opportunity to apply the tool in the private market, where the developer would not have an on-going property management relationship with the residents.

The developers were approached and asked to participate in the research, with the requirements for involvement, including consent, clearly explained. The process of conducting the case studies differed between the existing developments (26 Aroha and Oreil Avenue) and the development still in the planning stage.

At 26 Aroha and Oreil Avenue, all assessment methods within the framework were applied. These included:

- An independent site review.
- Developer's interview.
- Residents' survey.
- A CO_2 review.

The results were then collated and comparative scores provided to the developer, along with a summary of residents' responses and any additional feedback.

For the planned development, it was not possible to apply all the assessment methods, so an exploratory approach was used.

A summary of the three case studies is included in the following section.

6.2 Case study one - 26 Aroha

26 Aroha is a community-oriented and sustainably-driven 13-unit apartment block. Set on a 900m^2 site in Sandringham, Auckland, the development has been purposely designed as high quality, sustainable long-term rental, with leases of up to 10 years. It is the result of the developer's vision for better quality rental accommodation that builds community and minimises environmental impact.

Figure 3: 26 Aroha showing shared communal space on top floor (source: www.26aroha.nz)

Shared facilities make up 30 percent of the building area. These include a bookable guestroom for visitors, storage cages for each apartment and a communal bike/scooter storage space with e-bike charging points. The top storey is all communal, with a shared laundry, kitchenette, library, toybox, coffee machine, BBQ, and outdoor lounge. Outdoor spaces include communal vegetable beds and fruit trees, which are managed by interested residents and the developer.

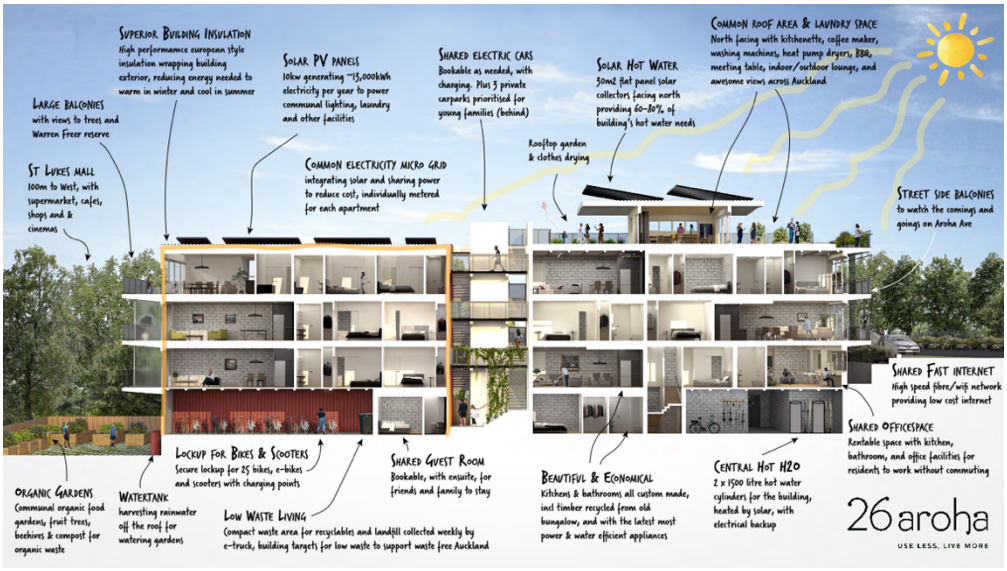


Figure 4: 26 Aroha cross-section with markup (source: www.26aroha.nz)

6.2.1 Independent site review, developer's interview and residents' survey

Beacon identified 26 Aroha as a useful example of exemplary practice in MDH. We contacted the developer, explained our research aims, and were invited to visit the site and find out more about their vision for the building. During this initial meeting, and the developers agreed to take part in a case study assessment.

The independent site review and developer's interview took place in mid-November 2022. The site review involved photographing key components, conducting a CO_2 review, and viewing two of the apartments. During the developer's interview, Beacon sought guidance on the most effective way to conduct the residents' survey. Since the residents had already been informed of the assessment, it was decided to distribute the project details and survey link through the resident's online forum. All 13 households responded and completed the online survey.

The data from the residents' survey, developer's interview and site review (including the CO_2 review) were then combined, analysed and presented as infographics. A summary of these results is included below.

6.2.2 Results

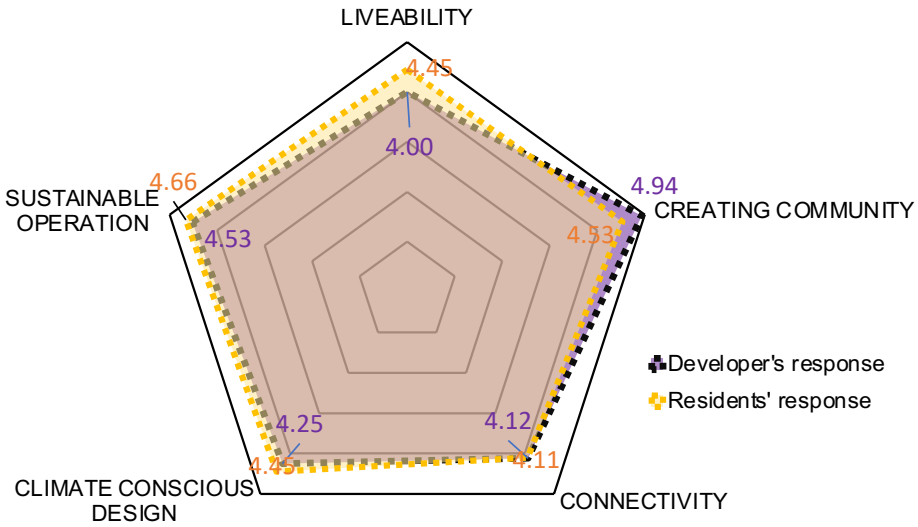
Living at 26 Aroha

A comparison of resident and developer perspectives

Residents and developers were asked to rate a range of aspects relating to their site, building, living spaces, and access to key destinations. The residents' average score for each topic has been adapted from their survey responses, while the developer's scores were collected during an interview and informed by the independent site review process. Scores are from 1-5 and are presented for the following five sections:

1. Liveability
2. Creating community
3. Connectivity
4. Climate conscious design
5. Sustainable operation

A broad comparison of residents and developer scores for each category can be seen below:



Each of the following sections outline the results in more detail with additional information that was collected from residents, and the developer, and during an independent site review.

Liveability

Providing quality facilities that meet residents' needs

	Residents	Developer
Dwellings and storage	4.38	4.50
Buildings and dwelling spaces were rated by residents and the developer for their appropriateness for mixed ages and abilities with suitability of storage for household needs	While rated highly, both the developer and a tenant noted that the upstairs shared space was not accessible by wheelchair. Several residents noted concerns regarding security around the cycle and storage units.	
Noise control and privacy	4.27	3.50
Ratings determined the extent to which design reduced noise to acceptable levels and also for building and unit orientation which meant that residents are not unduly overlooked during daily activities	None of the residents commented about noise nor privacy issues, and rated these higher than the developer. The developer noted that noise travels from the roof hub.	
Sense of place	4.54	2.00
A determination of site design, frontages and artistic works that create a cultural connection and a welcoming 'sense of place'	Residents rated sense of place higher than the developer, using phrases such as "appealing" "quality architecture", "amazing building" and "style". The developer noted the use of planting and sculptures to create a sense of place.	
Care and maintenance	4.85	5.00
A rating of plans, monitoring and implementation to regularly maintain the buildings, outside spaces and service major appliances	The developer noted regular cleaning and maintenance of shared spaces and gardens. Residents also rated highly how well the building and outdoor spaces are maintained	
Security and emergency preparedness	4.32	4.00
The extent to which security features and passive surveillance create a safe environment, while any emergency plans enhance resilience including provision of back up power and water should it be required	The developer noted high levels of community interaction, on-site water storage, solar power and a communal first aid kit, although no specific emergency preparedness plan. Both the residents and developer noted issues with people walking in off the street. Security cameras have been recently installed .	
Affordability and tenure	4.35	5.00
Comparative ratings assessed tenure options which provide residents with affordable housing that is flexible and secure	The developer and a resident noted the security of tenure with leases of up to 10 years available. The developer noted that other tenure options such as rent to own would change the dynamics of the development.	
Section Average	4.45	4.00

Liveability

Residents' ratings and responses

A word cloud representing three reasons residents chose to live at 26 Aroha

Creating community

Encouraging positive interactions between residents through design and facilitation

	Residents	Developer
Interaction by design	4.77	5.00
Getting together	3.63	5.00
Communication	4.88	4.75
Satisfaction	4.83	5.00
Section Average	4.53	4.94

Interaction by design

Ratings assessed the provision of indoor and outdoor spaces for communal purposes that encourage interaction

Communal spaces were rated highly by both residents and the developer. One resident suggested that the outdoor space at the back of Aroha could be further developed for get togethers and to play games.

Getting together

Residents determine the extent of of their physical interaction compared with any efforts by developers to build a trusting and resilient community

The residents indicated that they were happy with their level of interaction. All residents noted that they always, sometimes or would like to look out for each other. The developer noted that residents were beginning to set up groups based on mutual interests such as a book club.

Communication

A comparison of residents ability to easily communicate with each other and information and support they receive from developers to take part in decision making and minimise conflict

All residents rated the responsiveness of the property manager as excellent and also rated their ability to resolve issues with other tenants highly. The developer noted that there had been very little conflict between tenants and they worked things out themselves if needed.

Satisfaction

The extent to which residents and developers agree that the overall building and community creates a great place to live

Most residents strongly agreed that 26 Aroha is a great place to live. No residents disagreed with the statement.

Connectivity

Connecting infrastructure enables safe, universal access using active, assisted mobility, shared, and private modes of transport within and through the site to identified key destinations

	Residents	Developer
Accessibility to key destinations	3.45	4.61
Reducing travel by car	4.61	4.25
Safety, wayfinding and parking management	4.26	3.50
Section Average	4.11	4.12

The extent of accessibility to key destinations is based on distance, infrastructure and services that enable safe travel on foot, with mobility aids, by cycle, or frequent public transport or by private vehicle

The residents' rating shows their current use of different travel options. Active and public transport modes are used for over two thirds of their trips. The developers rating is generated by a desktop review of accessibility to key destinations by different modes. This is achieved by mapping destinations and assessing the ease with which they can be accessed by active, shared, and private travel options

Ratings identify the ease with which residents can reduce their car travel when appropriate compared with any support provided by developers that might encourage their active travel and use of public transport

Several respondents noted the central location as one of the reasons they chose to live at 26 Aroha. All respondents found it easy or very easy to access their local area on foot, with mobility support, or by bicycle. Reducing car use (while rated harder than using active modes) was rated as easy or very easy by most respondents. One residents noted their need for a car for work travel.

A comparison of ratings to assess design considerations that increase pedestrian safety around the site, efficient use of parking and suitable wayfinding that makes it easy for visitors, delivery and emergency services to find resident dwellings

Residents rated this higher than the developer, and both noted that pushchair access is currently being resolved.

Connectivity

More detail on residents' responses and the site review

Climate conscious design

Design that reduces embodied carbon and increases energy efficiency

	Residents	Developer
Habitat protection and climate consideration	4.81	4.00
Low impact durable design	4.92	4.50
Efficient low carbon building	5.00	4.25
Section Average	4.91	4.25

Residents ratings considered the importance of site selection that minimised the building's impact on the surrounding environment while reducing potential risks from climate change (flooding, fire and temperature changes). This is compared with a rating of the developer's actions to protect habitats and mitigate risks from climate change

All residents responded that it was very important to live in a building designed to reduce its impact on the local environment. All respondents indicated that they chose to live at 26 Aroha because of its environmental focus, ethos, and fit with their values. The developer noted that they already owned the site and the development process was designed to mitigate environmental impacts.

Residents identified the importance they placed on living in a building using materials that were designed to be long lasting with the ability to withstand earthquakes and climate effects and which can be easily deconstructed in future. Developers determined the extent to which these design factors were taken into account

Low impact durable design was important to both residents and the developer. The developer noted that they completed a lifecycle assessment over 100 years and that the materials were chosen for environmental impact including durability. However the developer noted that the development could have been more modular.

The importance of living in a building that minimised construction waste and used low carbon materials was compared with the developers actions to take a whole life cycle approach while making efforts to reduce embodied carbon of the construction

The developer noted that the building was custom designed for the site with low VOC and FSC materials and followed Living Building Challenge materials guidance. The use of concrete block and its carbon impact was noted. Green Gorilla was used for material recycling. Residents all rated it as very important to live in an efficient low carbon building.

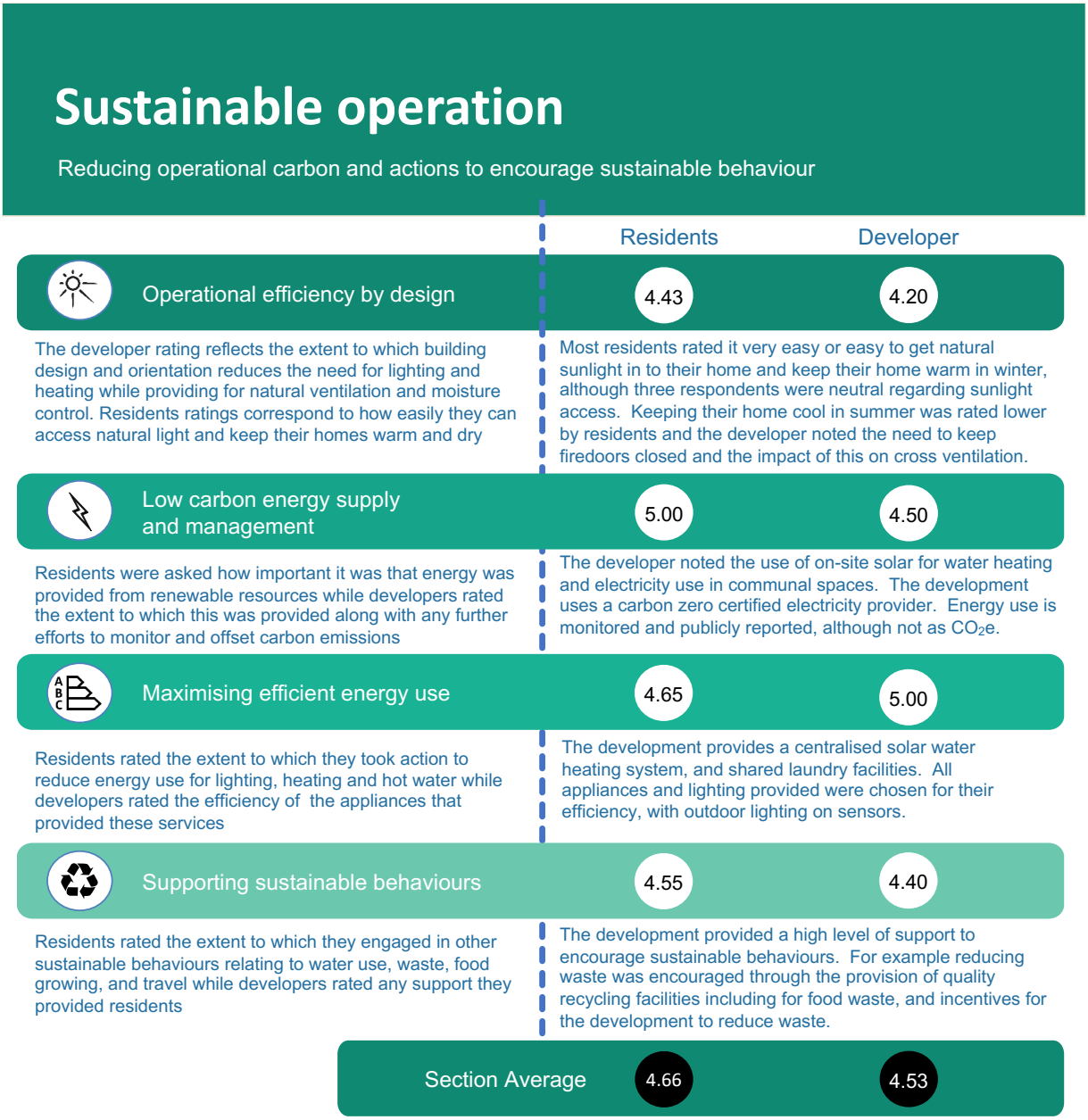


Figure 5: Living at 26 Aroha – Infographic comparison of residents' and developer's perspectives

6.2.2.1 CO_2 review

Beacon undertook a CO_2 review at the same time as the independent site review. Energy efficiency and reducing CO_2 was valued highly by both the developer and the residents at 26 Aroha. All residents rated it as very important *'that the energy that is used in the building is managed well and comes from renewable / low-carbon sources'.* Corresponding to this, the developer had invested heavily in local generation, energy efficiency and other actions to reduce CO_2. A number of detailed assessments had been undertaken which provided more information than the Beacon desktop CO_2 review. Given the investment made by the developer in the planning, building, and running of the apartments, Beacon's desktop review did not identify any areas where significant gains could be made in reducing CO_2.

6.2.3 Discussion

The developer's vision for 26 Aroha was better quality rental accommodation – creating a community of residents living in quality healthy homes, with secure tenure and having minimal impact on the planet. Turning the vision into reality was informed by best practice from both within New Zealand and overseas, and significant expertise supporting the three-year planning and design phase.

The review scores and resident feedback suggest the developer has achieved well on their vision. All but one respondent strongly agreed that both the building and the resident community make 26 Aroha a great place to live, and no one expressed disagreement. The scores reflect an alignment between the values of the residents and the developer. Further, the reason residents chose to live at 26 Aroha closely mirrored the developer's expectations, with sustainability, community, and apartment quality topping the list for both.

26 Aroha was an ideal site to test MDH-C for the first time. It demonstrated exemplary practice across the revised core outcome areas, particularly the importance of Creating Community as a cornerstone of sustainable development. Not only did the development reflect 'better practices', but the case study participants were highly engaged, well-informed and eager to learn. Residents' meetings were held to discuss the project and share findings, and both the developer and the residents indicated that they valued the process.

Given their knowledge and engagement, it is possible that both the developer's and residents' scores were influenced by their understanding of the issues and opportunities – a factor that should be considered when interpreting the results of future case studies.

The developer was generous in sharing learnings with Beacon and many others, and 26 Aroha provides an excellent example to inform future developments across Auckland and elsewhere. The success of this case study also gave the project team the confidence to test the expanded tool in other settings.

6.3 Case study two - Oreil Avenue

Oreil Avenue is a new community housing apartment block owned by CORT Community Housing and opened in October 2022. CORT Community Housing is a Registered Class 1 Social Landlord accredited by the Community Housing Regulatory Authority (CHRA). CORT owns approximately 380 community housing properties in Auckland and manages an additional 80 on behalf of other owners. CORT has applied MDH-1 across 11 of its developments and provides the associated reports on their webpage https://www.cort.org.nz/research.

With input from CORT, Oreil Avenue was designed and constructed by 3Group, a development and construction company comprising D3 Development, C3 Construction and B3 Buildings. Situated in Oreil Avenue, Massey, Auckland, the development comprises 15 self-contained apartment-units, set on an 809m^2 site. The apartment block has a building footprint of 317m^2 and was purposely designed and built as community housing. The three-storey complex comprises:

- 12x one-bedroom apartments – with three slightly different layouts to account for orientation and to provide two units with accessibility features.
- 3x two-bedroom apartments – all with identical layouts.

There are no shared indoor facilities, however outside shared facilities include communal vegetable planters, fruit trees, a garden shed, and parking.

Figure 6: Communal garden and fruit trees, Oreil Avenue

6.3.1 Independent site review, developer's interview and residents' survey

Beacon first visited Oreil Avenue at its official opening by then Minister of Housing, Megan Woods, in October 2022. Following meetings with CORT's Head of Development, Development Manager and the Tenancy Manager for Oreil Avenue, the Beacon Pathway interviewer was introduced to the tenants by the Tenancy Manager. This involved the Tenancy Manager delivering a simple handout to tenants alerting them to the project and then introducing the Beacon Pathway representative to them.

All tenants agreed to complete the survey except one who was away and was subsequently posted a copy of the questionnaire. Questionnaires were completed in October 2023.

Beacon undertook an independent site review in November 2023. This comprised:

- Reviewing the site, including for the same aspects included in the developer interview.
- Photographing areas of interest in the development.
- A CO_2 review with a focus on energy use - this included viewing inside one of the apartments.

The developer interview was undertaken with D3 Development in January 2024.

6.3.2 Results

Fourteen of the fifteen households completed the resident survey. The following infographic provides an overview of the responses from the developer and residents, giving an integrated picture to developers, enabling them to consider what works and doesn't work in their design, and where improvements might be made either to the existing development or in future developments. It enables comparison of what the developer believes they have achieved, with an independent site review and residents' views of what has been successful.

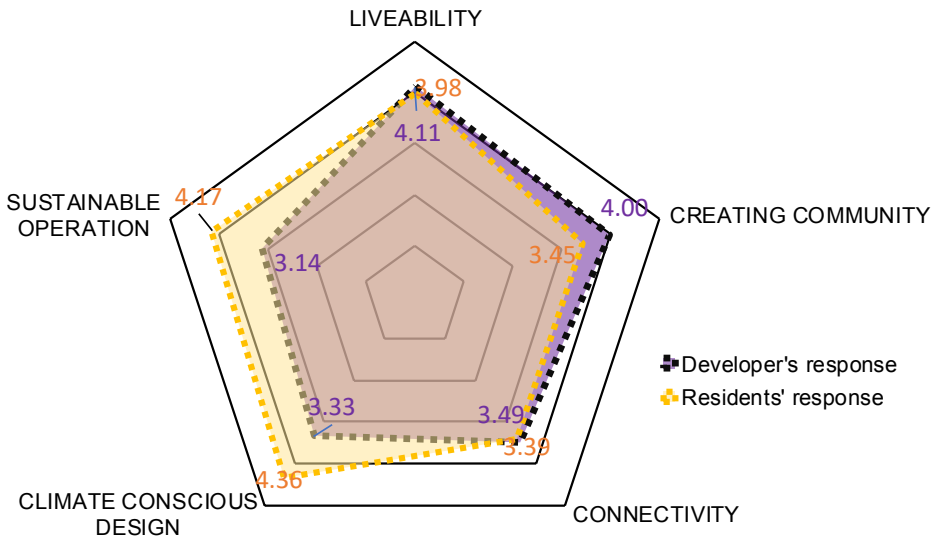
Living at Oriel Avenue

A comparison of resident and developer perspectives

Residents and developers were asked to rate a range of aspects relating to their site, building, living spaces, and access to key destinations. The residents' average score for each topic has been adapted from their survey responses, while the developer's scores were collected during an interview and informed by the independent site review process. Scores are from 1-5 and are presented for the following five sections:

1. Liveability
2. Creating community
3. Connectivity
4. Climate conscious design
5. Sustainable operation

A broad comparison of residents and developer scores for each category can be seen below:



Each of the following sections outline the results in more detail with additional information that was collected from residents and the developer and during an independent site review.

Liveability

Providing quality facilities that meet residents' needs

	Residents	Developer
Dwellings and storage	4.07	4.00
Buildings and dwelling spaces were rated by residents and the developer for their appropriateness for mixed ages and abilities with suitable storage for household needs.	Both the developer and a tenants noted the stairs were a constraint for some tenants. Tenants generally thought there was a good amount of storage, although some raised the need for more shelving, and dampness and mould in cupboards.	
Noise control and privacy	3.93	5.00
Ratings determined the extent to which design reduced noise to acceptable levels, and also for building and unit orientation which meant residents are not unduly overlooked during daily activities.	Dwellings are designed to avoid noise transfer. Several residents raised noise as an issue, including from the broader community (nearby school and community hub).	
Sense of place	4.31	3.00
A determination of site design, frontages and artistic works that create a cultural connection and a welcoming 'sense of place'.	Residents rated sense of place higher than the developer, noting the adjacent park and birds, and used phrases like 'nice'. The developer noted how the development fronts the street.	
Care and maintenance	4.08	4.00
A rating of plans, monitoring and implementation to regularly maintain the buildings, outside spaces and service major appliances.	A full development pack had been provided by the developer to CORT who are responsible for care and maintenance. This was rated highly by both the developer and residents.	
Security and emergency preparedness	3.45	3.67
The extent to which security features and passive surveillance create a safe environment, while any emergency plans enhance resilience including provision of back-up power and water should it be required.	Residents and the developer provided slightly lower ratings, raising concerns about their feeling of safety and some antisocial behaviour both within the development and the broader neighbourhood.	
Affordability and tenure	4.04	5.00
Comparative ratings assessed tenure options which provide residents with affordable housing that is flexible and secure.	Thirteen of the fourteen tenants agreed or strongly agreed that they were happy with their rental arrangements. While affordability was rated slightly lower than tenure, several tenants noted that the issue was general living costs.	
Section Average	3.98	4.11

Liveability

Residents' ratings and responses

A word cloud representing three reasons residents chose to live at Oriel Ave

Creating community

Encouraging positive interactions between residents through design and facilitation

	Residents	Developer
Interaction by design	3.27	2.00
Ratings assessed the provision of indoor and outdoor spaces for communal purposes that encourage interaction.	The residents raised several opportunities, including outdoor seating and activities such as barbeques to encourage the use of outdoor spaces. The developer noted that more bump spaces could be useful in creating community.	
Getting together	2.84	5.00
Residents determined the extent of of their physical interaction compared with any efforts by developers to build a trusting and resilient community.	Residents rated their involvement with other tenants much lower than the developer, and much lower than for other areas of the survey. “Looking out for other residents’ health or safety when they need support”, was rated far higher than other interactions.	
Communication	3.77	5.00
A comparison of residents’ ability to easily communicate with each other, and the information and support they receive from developers to take part in decision making and minimise conflict.	Residents in general found it easier to communicate with the tenancy manager than between themselves, particularly when raising issues.	
Satisfaction	3.91	4.00
The extent to which residents and developers agree that the overall building and community creates a great place to live.	The developer noted this was the first time they had been involved with community housing and were very proud of the outcome. Residents’ views were varied, although in general were happy, saying things such as, “Cool, I like it, I’m happy. One of the best places I’ve been.”	
Section Average	3.45	4.00

Connectivity

Connecting infrastructure enables safe, universal access using active, assisted mobility, shared, and private modes of transport within and through the site to identified key destinations

	Residents	Developer
Accessibility to key destinations	2.89	3.98
Reducing travel by car	3.76	2.50
Safety, wayfinding and parking management	3.52	4.00
Section Average	3.39	3.49

The extent of accessibility to key destinations is based on distance, infrastructure and services that enable safe travel on foot, with mobility aids, by cycle, or frequent public transport or by private vehicle.

The residents' rating shows their current use of different travel options, taking active and public transport modes for nearly 60% of their trips. The developer's rating is generated by a desktop review of accessibility to key destinations by different modes. This is achieved by mapping destinations and assessing the ease with which they can be accessed by active, shared, and private travel options.

Some residents noted health constraints that limited their ability to walk to destinations and, in some cases, use public transport.

Ratings identify the ease with which residents can reduce their car travel when appropriate, compared with any support provided by developers that might encourage their active travel and use of public transport.

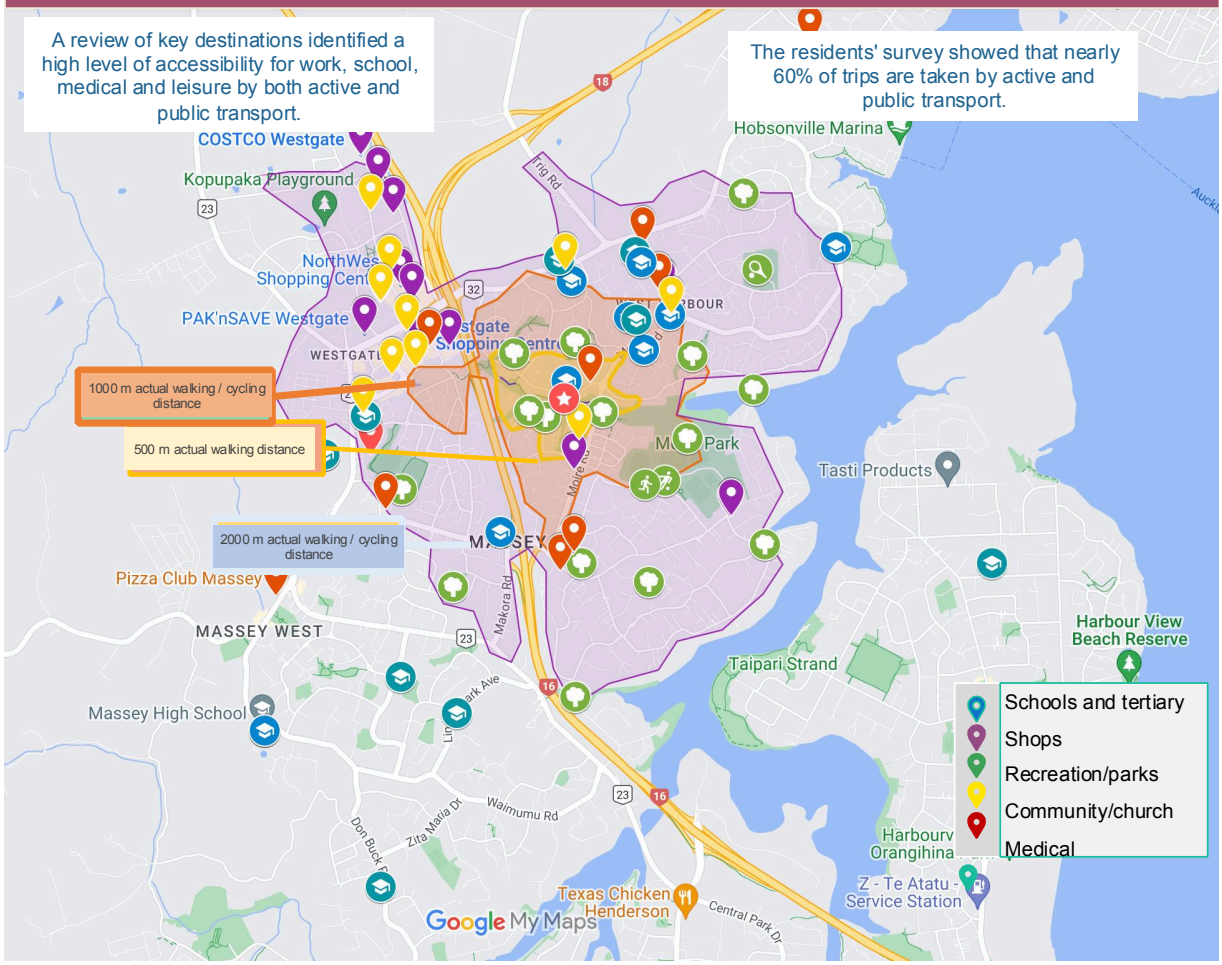
Both the residents and developer noted the nearby bus stops, with residents mentioning the bus services at numerous times in the survey. The developer also noted nearby cycleways, and that more could be done to provide information on bus routes and walking and cycling access.

A comparison of ratings to assess design considerations that increase pedestrian safety around the site, efficient use of parking and suitable wayfinding that makes it easy for visitors, delivery and emergency services to find resident dwellings.

The developer noted the separate pedestrian entrance for safety. Residents provided the most comments about parking and concerns with the stairs and their safety. Resident comments were varied, from supporting the current need-based system (both from those who had an on-site park and those who didn't) through to concerns about on-site parking disagreement with other residents.

Connectivity

More detail on residents' responses and the site review



Climate conscious design

Design that reduces embodied carbon and increases energy efficiency

	Residents	Developer
Habitat protection and climate consideration	4.09	4.50
Low-impact durable design	4.80	2.50
Efficient low-carbon building	4.20	3.00
Section Average	4.36	3.33

Residents' ratings considered the importance of site selection that minimised the building's impact on the surrounding environment, while reducing potential risks from climate change (flooding, fire and temperature changes). This is compared with a rating of the developer's actions to protect habitats and mitigate risks from climate change.

Both the residents and developer rated habitat protection and climate consideration highly. The developer is ISO 14001 certified, the site is not within an overland flow path, and retention and detention ponds are provided under the driveway.

Residents identified the importance they placed on living in a building using materials that were designed to be long lasting with the ability to withstand earthquakes and climate effects, and which can be easily deconstructed in future. Developers determined the extent to which these design factors were taken into account.

The residents rated the importance of low-impact design highly, despite most open-ended comments being more about how they enjoyed having their own space or were grateful for a home. The developer had not sought third-party verification, such as GreenStar, but had taken account of available information, such as designing for 1 in 100-year flooding.

The importance of living in a building that minimised construction waste and used low-carbon materials was compared with the developer's actions to take a whole life cycle approach while making efforts to reduce embodied carbon in the construction.

The developer took a number of actions, including using similar design across units, reduced material types to simplify future maintenance, and being ISO certified for waste management. The developer also noted that they are working with their architects more in early design to look at the life-cycle of material.

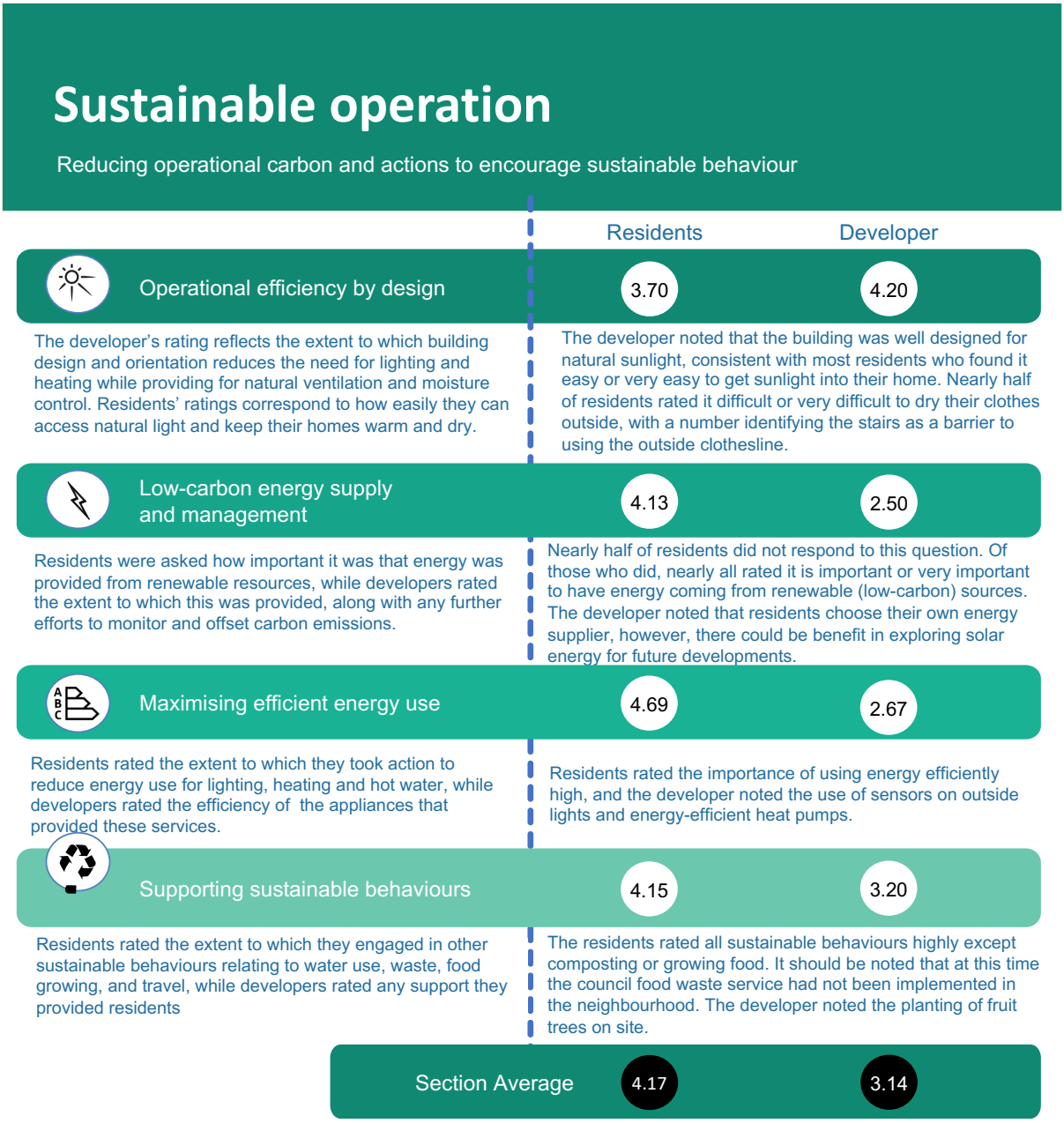


Figure 7: Living at CORT Oreil Avenue – Infographic comparison of residents' and developer's perspectives

6.3.2.1 CO_2 review

As part of the site review, Beacon undertook a CO_2 review at Oreil Avenue using the methodology outlined in Appendix Three. The developer had considered sustainability in their planning; however, they had not undertaken an embodied carbon analysis.

As a result of this review, the following actions were suggested, recognising that CORT is balancing a number of priorities including ease of use and replacement, durability and efficiency:

- Ensure sensors are used on all outdoor lighting, if not already.
- Provide external venting for laundry dryers and assist residents in mounting the dryers.
- Consider installing a rainwater capture system for emergency and outdoor use.
- Install moveable external shading on the north and west if over-heating becomes an issue.
- Provide more detailed information on waste and reducing energy and water use including appliance running costs and advice for purchasing appliances in the tenant's manual or similar documents.

For future developments, the following are suggested for consideration:

- Undertake embodied carbon calculation in future developments to minimise embodied carbon where possible.
- Consider thermal modelling of buildings to optimise, orientation, insulation and glazing levels.
- Consider lifecycle impacts of all building products.
- Consider cleaning, maintenance and replacement implications of design and material use.
- Manage domestic (builder's) waste on site to reduce impact on site and contamination of other managed waste streams. This is in addition to managing building waste on site.
- Ensure all appliances and fixtures are energy and water efficient.
- Investigate on-site generation of energy such as communal hot water with direct PV to hot water. An energy audit should be undertaken prior to any on-site generation.

6.3.3 Discussion

Oreil Avenue has been designed to provide quality, affordable homes for residents needing community housing. The development adds to CORT's housing portfolio in a locality well served by the local bus networks and a safe walk to a range of facilities including medical services, a pre-school and primary-school and the Westgate shopping centre.

From the residents' survey and developer's interview, scores were developed across each of the five core outcomes. There was some variability between the developer's and residents' scores across a number of core outcome and between the core outcomes. The scores and comments from residents were generally positive, although several residents indicated that there had been on-going dampness issues which had affected how much they enjoyed living in their home.

Overall, residents rated Liveability very slightly lower than the developer, with the areas of significance difference between residents and developer's responses being:

- Residents rated noise control and privacy slightly lower than the developer, noting some noise from the broader community and within the development.
- The developer scored sense of place, lower, noting that they had put effort into how the development addressed the street and provided a small amount of façade detail, but could have done more.
- The residents rated affordability and tenure lower than the developer. When responding to this question, several residents noted that unaffordability was related to overall cost-of-living rather than just the rent level.

Residents' scores were lower for Creating Community than the developer, with residents generally indicating a preference to keep to themselves. However, residents responded far more positively to '*Looking out for other residents' health or safety when they need support'.*

Residents were less likely to respond to Climate Conscious Design questions, however those who responded tended to value environmentally friendly approaches to building and actions to reduce climate change highly. Higher residents' scores for Sustainable Operation reflected residents' actions to maximise efficient energy use and undertake other sustainable behaviours such as using water efficiently and recycling.

There was some alignment between the reasons the residents chose to live at Oreil Avenue and the main reasons that the developer felt someone would choose to live there. However, the most frequent response from residents was an appreciation of having a home and their own space.

Table 6: Three main reasons for choosing to live at Oreil Avenue - residents and developer

Residents' reasons (number of comments)	Developer reasons
■ Having their own space and having a home (8 comments). ■ Proximity to places and services (8 comments) with several examples being mentioned: – reserve, doctors and walking accessibility to everything (2 comments each) – shops and whānau (1 comment each). ■ Safe and quiet (5 comments). ■ The people (4 comments), including 3 comments about other tenants and one about the tenancy manager. ■ Nice and new (3 comments). ■ Suits lifestyle (3 comments).	■ Location – close to schools, backing on to the reserve and green belt and the easy cycle and bridge access including to the shopping centre. ■ The design of the units noting the generous internal space and that these are not small for one-bedroom units/ generous open-plan living space - more storage space (CORT requirement). ■ Community gardens and fruit trees (CORT-led design features).

Oreil Avenue provides a useful test of MDH-C with a developer Beacon has worked with for a number of years who was working alongside a new developer. In general, respondents were positive about living at Oreil Avenue, although issues with dampness and between residents meant that some residents felt unhappy with some aspects of their home.

6.4 Case study three – a planned group-home-builder development

The proposed development is high-end MDH set on a prominent site in a well-known holiday town. The development consists of 10 three-bedroom dwellings of approximately 200 m^2 each, targeted at holiday-home owners. The water-front site is adjacent to a large reserve, and about one kilometre from the town centre, connected by walking and cycle ways.

Because of its prominence in the town, efforts had been made to ensure the planned development has high amenity values and creates a positive impact on the local landscape. For instance, the number of properties on the site has been restricted, compared with what the district plan allows, and the design captures a 'local' feel and the connection with the adjacent reserve has been emphasised.

6.4.1 Plan review, desktop assessment of connectivity and developer interview

Because the development is still in the planning stages a different approach was taken than in the first two case studies. Rather than applying all the methods in the tool and generating comparative scores, we took an exploratory approach. We:

- Assessed the development off the plans using the site review framework in the tool. This assessment informed our developer interview.
- Undertook a desk-based assessment of connectivity.
- Conducted a semi-structured interview with the developer using the developer's interview method in the tool to guide the discussion.

From this, Beacon assigned interim independent scores to the development and made a set of recommendations for the developer to consider for this or future projects. In some sub-categories, there was insufficient information to generate a score or a question was not applicable in the context. In these cases, the item was not given a score. This does not affect the overall score for that section. It was not possible to conduct a carbon assessment of the development as there was not enough information available about lighting and appliance design or specification.

Once the development has been built and occupied, there is an opportunity for Beacon to apply the complete tool methodology. The value in applying it at the planning stage is that recommendations can be more readily considered for incorporation into the plans than when the development is built.

6.4.2 *Results*

The developer was asked about actions taken in relation to a range of aspects relating to their site, building, living spaces, and access to key destinations. At this preliminary stage, the developer has not been asked to score their responses. Instead, Beacon has made an interim independent assessment based on a review of the plans and an interview with the developer. In some cases there is still insufficient information to generate a score or a question is not applicable in the context of the development. In these cases it does not affect the score for that section. Scores are from 1-5 and are presented for the following five sections:

1. Liveability
2. Creating community
3. Connectivity
4. Climate conscious design
5. Sustainable operation

Each of the following sections outline the results in more detail with additional information that was collected from residents, and the developer, and during an independent site review.

Liveability

Providing quality facilities that meet residents' needs

	Beacon interim score
Dwellings and storage	3.00
Appropriateness of buildings and dwelling spaces for mixed ages and abilities with suitability of storage for household needs.	Storage appropriate for anticipated use of dwellings – especially sporting and recreational activities. All dwellings have potential for increased accessibility not yet realised.
Noise control and privacy	4.00
Extent to which design reduced noise to acceptable levels and also for building and unit orientation which meant that residents are not unduly overlooked during daily activities.	Dwellings designed to avoid noise transfer between inter-tenancy walls where possible. Dwellings staggered and balconies have solid sides to avoid over-looking.
Sense of place	4.00
A determination of site design, frontages and artistic works that create a cultural connection and a welcoming 'sense of place'.	Site plan indicates careful consideration of these elements. Won't be possible to fully assess before development has been constructed.
Care and maintenance	2.00
A rating of plans, monitoring and implementation to regularly maintain the buildings, outside spaces and service major appliances.	Developer would like to do more to support occupants with operating the building– e.g. passive ventilation, managing internal moisture, energy efficient behaviour.
Security and emergency preparedness	2.67
The extent to which security features and passive surveillance create a safe environment, while any emergency plans enhance resilience including provision of back up power and water should it be required.	Residents expected to install security systems though some dwellings have good street surveillance and passive security. No plans yet of exterior lighting. No plans for onsite water collection and storage or back up power generation.
Affordability and tenure	N/A
Assessment of tenure options which provide residents with affordable housing that is flexible and secure.	It is assumed that all dwellings will be sold to private owners.
Section Average	3.13

Creating community

This section looks at actions that facilitate positive interactions between residents and create a sense of trust which is an essential foundation for resilient and sustaianble communities

Beacon interim score

Interaction by design

2.00

Provision of indoor and outdoor spaces for communal purposes that encourage interaction.

Site has shared outdoor space and connectivity to adjacent reserve which allow for interaction between residents. Potential to enhance site to encourage more interaction without necessitating interaction if it is unwanted.

Getting together

N/A

Efforts by developers to build a trusting and resilient community.

Communication

N/A

Developers support residents with information about the property and conflict between residents is minimised or mediated.

Satisfaction

N/A

The extent to which residents and developers agree that the overall building and community creates a great place to live

Section Average

Connectivity

Connecting infrastructure enables safe, universal access using active, assisted mobility, shared, and private modes of transport within and through the site to identified key destinations

Beacon interim score

Accessibility to key destinations — 2.93

The extent of accessibility to key destinations is based on distance, infrastructure and services that enable safe travel on foot, with mobility aids, by cycle, or frequent public transport or by private vehicle

The site has good walking and cycling connectivity with nearby cycle path leading to the town centre – approximately 1.5 km. Well situated for access to recreation. Very limited public transport options and travel to shopping, including supermarkets and some community facilities, likely to require a private vehicle.

Reducing travel by car — 3.00

Ratings identify the ease with which residents can reduce their car travel when appropriate compared with any support provided by developers that might encourage their active travel and use of public transport.

Site is well positioned to access local amenities by active means. It is across the road from walking and cycling paths. Also suitable for scooters. Parking is scarce and expensive in town so walking and cycling is attractive. Garages provide separate space for bike storage.

Safety, wayfinding and parking management — 3.00

Design considerations that increase pedestrian safety around the site, efficient use of parking and suitable wayfinding that makes it easy for visitors, delivery and emergency services to find resident dwellings.

Plans show consideration has been given to reducing conflict between cars and other users. However plans could benefit from expert review. Some questions in this area could not be rated off the plans.

Section Average — 2.98

Climate conscious design

Design that reduces embodied carbon and increases energy efficiency

Beacon interim score

Habitat protection and climate consideration — 3.50

Actions to protect habitats and mitigate risks from climate change.

Site is removed from any flooding risk, this is part of the developer's standard site assessment. All soil removal carefully managed and monitored by council. Development has extensive planting plan.

Low impact durable design — 2.50

The extent to which developers considered using materials that were designed to be long lasting with the ability to withstand earthquakes and climate effects and which can be easily deconstructed in future.

Building are designed to meet or exceed building code requirements. Guttering is higher volume than standard to account for higher-than-average rainfall in future. No assessment of embodied carbon has been undertaken.

Efficient low carbon building — 2.00

Developer's actions to take a whole life cycle approach while making efforts to reduce embodied carbon of the construction.

Developer has onsite waste management and separation of waste. Waste minimisation and reducing wastage of materials is part of efficient business practice. Do not use 3rd party labelling but have guidelines for suppliers and sourcing materials. Whole life cycle impact of materials not assessed.

Section Average — 2.67

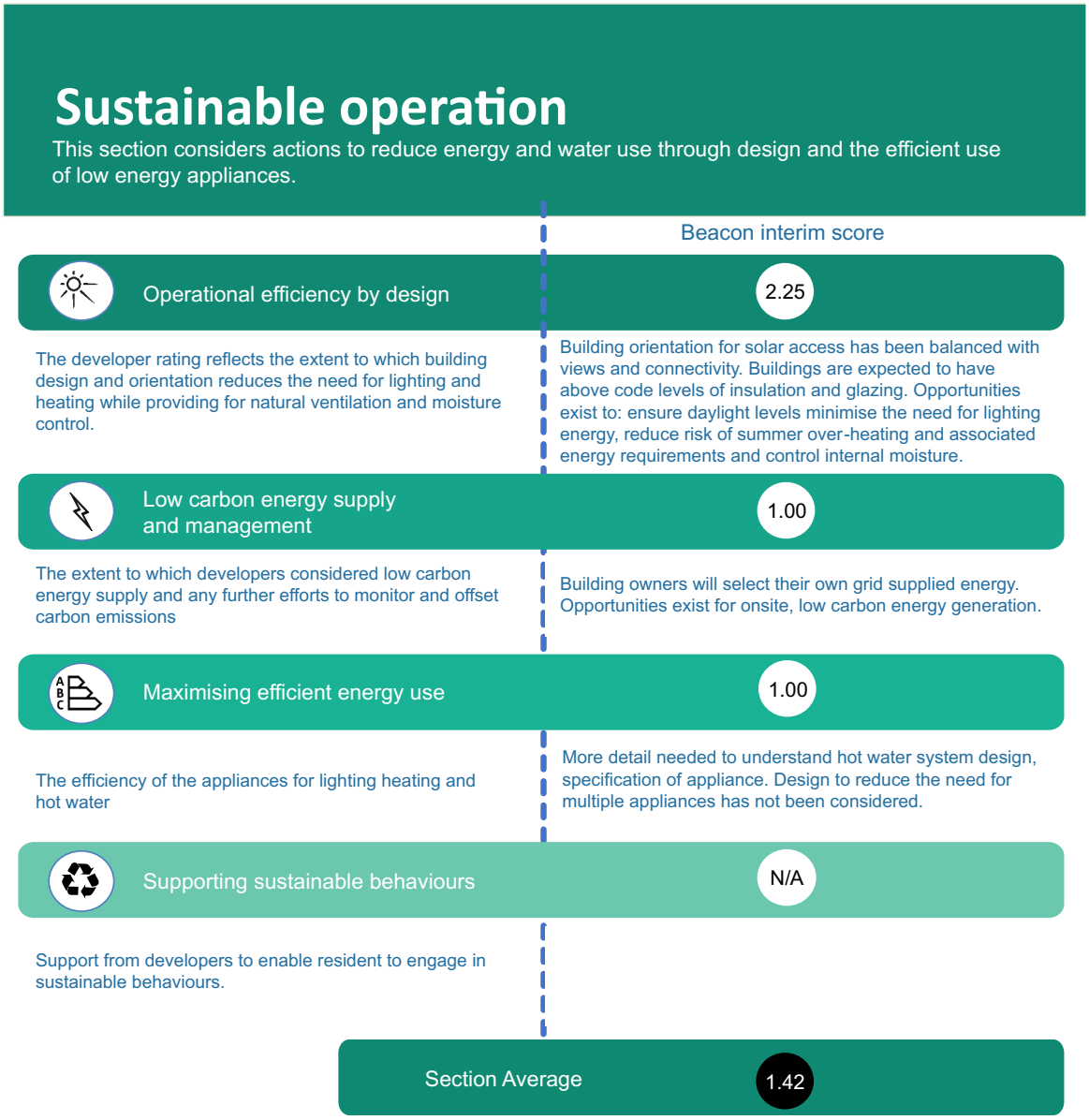


Figure 8: Planned group home builder development – Infographic of interim assessment

6.4.3 Recommendations

As a result of our assessment of the proposed development, the following recommendations have been made to the developer.

Table 7: Recommendations from the assessment

Outcome area	Recommendations
Liveability	■ Include design features that can be easily adapted to the changing needs of occupants, both short-term (e.g. from an accident) and as they progress through life. This means a change in a person's circumstances does not require an expensive retrofit so they can continue to live safely and independently in the home, or for them to move. These design features may not be noticeable (e.g. wall construction so that a handrail can be added later) but will facilitate adaption later for little cost. ■ Make at least one bedroom and one bathroom in each dwelling 'accessible' (or easily adaptable to be accessible). We recommend investigating the downstairs bedroom and bathroom, which from the plans, appear to require fairly small changes in order to: – Increase door widths. – Ensure turning areas are sufficient for a wheelchair. – Ensure bathrooms are either accessible (e.g. meeting Lifemark® guidelines) or easily adapted to be accessible (e.g. allow for appropriate bracing in walls). ■ Ensure turning circles at the lift entry and exit enable wheelchair access. ■ Provide all new homes with an operating manual that includes guidance around living in the home (e.g. passive ventilation, internal moisture control), the importance of on-going maintenance and the benefits of energy efficient appliances. This could be incorporated with existing systems to provide manuals and a maintenance schedule. ■ Include provision for water capture and retention on site for emergency use. ■ Plans indicate careful consideration of elements of the tool related to Sense of Place. It won't be possible to fully assess before development has been constructed. Review these questions post-construction.
Creating Community	■ Consider enhancing the outdoor space to encourage more opportunities for interaction (e.g. putting a BBQ or fire pit by the pergola). ■ Consider providing some shared facilities (e.g. clothesline, boat cleaning facilities). ■ Undertake residents survey in relation to these aspects of the tool once the homes are occupied.
Connectivity	■ Provide owners with information on walking, cycling and public transport options in both hard copy and electronic format. ■ Seek review of plans by a parking safety expert to ensure safety of people moving around the site when vehicles are present. ■ Ensure that site signage is clear, with a primary focus on emergency vehicle navigation, and vehicle and visitor needs.
Climate conscious design	■ Consider cleaning, maintenance and replacement implications of the design and materials selected. For example, timber detailing on second storey may require scaffolding for cleaning and therefore runs the risk of not being regularly cleaned. This may lead to more a frequent need for maintenance and replacement. Cladding needs particular consideration due to its 15-year expected life-time under the Building Code. ■ Consider lifecycle impacts of all building products.

Outcome area	Recommendations
	■ Utilise embodied carbon calculation methods for future developments to minimise embodied carbon where possible. ■ In addition to the building waste management already planned for the site, manage domestic (builder's) waste to reduce impact on site and contamination of other managed waste streams. ■ Consider benefits of off-site construction in future developments, where applicable.
Sustainable Operation	■ Consider thermal modelling of buildings to optimise orientation, insulation and glazing levels. ■ Consider including moveable external shading on the north and west to prevent over-heating ■ Install extract ventilation with moisture sensor in the garages to mitigate the effect of sports and water gear (e.g. boats, ski gear) being locked in the garage when wet. ■ Seal door between garage and house to prevent moisture and vehicle fumes getting inside the dwelling. ■ Specify energy and water efficient fixtures and appliances including: ■ Instal low flow taps, low-flush toilets and showerheads with a flow-rate of less than 9 litres/min. ■ Provide energy and water efficient appliances, where these are provided by the developer. ■ Consider energy and water efficiency when providing appliance packages to purchasers. ■ Provide an outside drying area (also see recommendation above re: shared washing line) ■ Investigate on-site generation of energy such as for communal hot water with direct PV to hot water. An energy audit should be undertaken prior to any on-site generation. ■ Consider installing a rainwater capture system for emergency and outdoor use. ■ Investigate installing an on-site food waste management system.

6.4.4 Discussion

The proposed development is a high-quality MDH development aimed at holiday-home owners. Because of its prominence in the town, efforts have been made to ensure it has high amenity values and creates a positive impact on the local landscape. The development is of a good quality design and feel – the developers understand their market and are responding to that.

Beacon has provided interim scores for each of the tool's core outcome areas. These are based on a review of the plans, using the site assessment framework, and a semi-structured interview with the developer. The interim scores highlight that in many areas the proposed development is expected to perform very well. For example, the scores for Liveability and Connectivity reflect a well-considered design with a good range of quality facilities and features on a well-positioned site. There are also areas where there are opportunities to significantly increase the scores. These are mainly in the areas of Climate Conscious Design and Sustainable Operation and Behaviour.

We note that the questions related to Creating Community were not straightforward to apply in the context of this development. This is partly to do with the intended use of the dwellings. We recognise that some of the questions are more easily applied in a setting where the developers have an on-going

property/facilities management role and on-going relationship with the residents. There are also several questions in this outcome area that cannot be answered until the buildings are built and occupied.

This case study differed from the others in a number of significant ways, providing an opportunity to test the tool in a different context. Firstly, the development has not yet been built, so the assessment was carried out 'off-the-plans'. Secondly, the dwellings are being built for the private (holiday-home) market, meaning the residents will have different needs and expectations than residents at 26 Aroha or Oreil Avenue and the plans for the development reflect that. Further, because of the predicted tenure arrangements of the properties once sold, the development will have different on-going property management arrangements compared with the other two case studies.

Applying the tool in this context offered Beacon the opportunity to test:

- The applicability of the tool off the plans – to understand the trade-offs that would be necessary, how well the existing methodology could be applied in this context and what else works well or does not.
- The applicability of the tool in a different segment of the MDH market,
- Whether early engagement with the tool could lead to greater consideration of the core outcome-focussed principles in the tool by the developer.
- The usefulness to the developer of assessing a development prior to consent and construction (when changes can still be made).

It was understood at the outset that there would also be some trade-offs by testing the tool on an unbuilt development. For example, it was not possible to carry out the residents' surveys or the site survey. However, it provided an opportunity to make specific recommendations that will be considered by the developer before the plans.

7 Case study findings and further insights: refining MDH-C

Beacon used case studies as a method to test MDH-C and, in particular, to understand:

- The value of the tool to encourage and enable developers, and other stakeholder, to plan, design and commission better practice, low-carbon MDH.
- How well the revised core outcomes (and their sub-categories and associated questions) enabled consideration of operational and embodied carbon in the framework. This included understanding whether the core outcomes were comprehensive and well-integrated and that the sub-categories and questions were well-defined, appropriately categorised, clearly worded and without duplication or unnecessary elements.
- The value, applicability and ease of delivery of the desktop CO_2 review.
- The role and value of the proposed self-assessment version including the guidance that would be required for developers, or other users, to apply the tool themselves.
- Whether the framework was applicable in a range of contexts, including in the planning stages, and what modifications, if any, that might require.

Several months after the case studies were completed, Beacon held follow-up conversations invited the three case study developers to have follow-up conversations to understand:

- Whether the assessment process and the reports were of value.
- What the process of applying the tool was like and if there were ways we could improve it.
- Whether any changes had been made (physical or changes in thinking) as a result the process.

Two of the three case study developers were able to take up this opportunity. During the project we also gained insights from engagement with sector stakeholder and from applying MDH-C in a Kāinga Ora development. Although the Kāinga Ora work was outside the scope of this research, the insights from that project did inform our final amendments to MDH-C.

7.1 Insights from the case studies

7.1.1 MDH-C is valuable and applicable in a range of contexts

The case studies demonstrated that the tool is applicable across a range of segments of the MDH market – from social housing to private rentals and high-end privately-owned holiday homes.

MDH-1 had a track-record in a social housing context, and it was useful to have this consistent benchmark when testing the revised tool. It enabled us to test the relative benefits of the amendments to MDH-1 distinct from the rest of the tool. We were also fortunate to have the opportunity to test the tool against a local example of exemplary practice, demonstrating many of the better practice concepts outlined in the international tools and guidance. The willingness of the developers and the community of residents at 26 Aroha to engage with the research and share their experiences was also extremely valuable. It provided tangible, local evidence to support our discussions with others about the core outcomes and their benefits. In this context MDH-C was seen as more practical and less theoretical.

The group-home-builder case study was the first time the tool (MDH-1 or MDH-C) had been applied on an unbuilt development. The experience showed that MDH-C was both useful and applicable in this context although some adaptations were required. For instance, it wasn't possible to carry out the residents' survey and we didn't ask the developer to assign scores as some questions were not yet applicable. Instead, we applied interim scores based on the independent review of the plans and an interview with the developer. The tool was sufficiently flexible to adapt it in this way without affecting its integrity or the value to the developer.

Most importantly, applying the tool to an unbuilt development enabled Beacon to start an on-going conversation with the developer that opened them up to making changes. It allowed us to provide a set of targeted recommendations and to introduce concepts they have previously considered were not directly applicable to their market. For instance, the developer originally considered some aspects of Creating Community were not relevant to the holiday-maker market. But through the process of engaging with MDH-C they could see the potential value of these features. Other feedback from the same developer was that the set of recommendations, and Beacon's independence, were valuable when suggesting changes to other stakeholders, including the land-owners. They did note, however, that where the scores were lower it was important to provide sufficient context with the recommendations, so that the low scores are not discouraging.

The tool was tested in two existing developments built within the last few years (Oreil Avenue and 26 Aroha). Both their age of the developments and an existing focus on sustainability meant they already had better practice lighting (e.g. LEDs, sensors) and other energy efficient devices. As a result, the benefit of the desktop CO_2 review was less than originally envisaged. We anticipate there would be greater CO_2 reduction potential in an older existing development and Beacon will seek opportunities to test MDH-C in this context.

7.1.2 Tool enables conversations among a range of interested parties and has an educational role

The tool's primary function is to provide a user with comparative perspectives on the extent to which a development responds to the core outcomes. However, the case studies reinforced that there is wider value in the framework to educate and encourage behaviour change.

As alluded to above, the tool provided a framework to start a conversation with a developer who initially considered certain features of the core outcomes were not relevant. Through their engagement with Beacon that perspective changed. It also provided a structured way for them to take the recommendations that arose from our assessment back to other decision-makers.

Another example of the tool providing a framework for behaviour change is the way the 26 Aroha developers used the report. All residents were provided with a copy of the full report and a hui held to discuss potential actions arising from it. The agreed actions formed the basis for ongoing conversations between the developer and residents.

This indicated there may be value in understanding how the developer may use the report prior to undertaking the assessment, for example, the intended end user could impact on the level of explanation required in the report. Beacon has added a question to the preamble of the assisted-assessment tool, to better understand how the report may be used.

One developer raised the potential usefulness of re-applying the tool in a development, both to monitor changing resident perspectives and to engage a new cohort of residents.

7.1.3 Tool is adaptable within limits

One developer was interested in customising the residents' survey to include additional tailored questions. We have received similar requests when applying MDH-1. While there may be some benefit to adding bespoke questions on a case-by-case basis this needs to be balanced with ensuring the integrity of the framework and the length of the survey (and corresponding time for residents to complete it).

The case study with the planned development also showed that the framework could respond to different contexts without risking its integrity.

7.2 Revisions to MDH-C

In response to these findings, we made some final revisions to the tool. They relate to the structure and detail underpinning the core outcomes, the desktop CO_2 review and the self-assessment version of the tool.

7.2.1 Revisions to core outcomes, sub-categories and questions

The new core outcomes, sub-categories and questions generally worked well in the case studies. The framework was coherent and comprehensive. Nonetheless, there were opportunities to refine it further.

The Sustainable Operation core outcome was re-framed as Sustainable Operation and Behaviour. This was to emphasis the role of occupant behaviour in reducing operational emissions and resource use more generally. We also made a minor editorial tweak: changing Climate Conscious Design to Climate-Conscious Design.

Some minor tweaks were also made to the sub-categories within some of the core outcomes. For instance, in the Liveability section Dwelling Design and Storage were separated into two sub-categories to emphasise the importance of both.

Some minor changes were also made to the wording of the question to make the language simpler and clearer and to ensure alignment between the developer's and residents' questions.

Guidance was strengthened and refined in several other areas, notably refining the examples of better practice and providing stronger guidance on scoring. For example, in some applications of the tool response rates for Climate-Conscious Design questions were lower, along with those responding tending to value the attributes more strongly than other attributes in the survey. Reporting has been strengthened to include number of respondents and text raising any issues, where required.

7.2.2 CO_2 review valuable in some contexts

The CO_2 review was designed to calculate operational energy consumption and estimate resulting emissions. However, the case studies highlighted that the assessment identified fewer opportunities for

savings and was more difficult to apply than originally intended. The occupied developments were newly built and therefore lights and appliances were already relatively energy efficient. This limited the energy savings and emissions reductions that could be identified through the review. In addition, the assessment process was relatively time-consuming, adding time and complexity to our engagement with the case study residents and developers. As a result, we have concluded that the CO_2 review does not add significant value in a new development. In such cases, Beacon would recommend that the developer considers a more complete CO_2 modelling exercise. Any more general recommendations, that could lead to improvements in energy efficiency (e.g. appliance installations and usage, lighting, heating, cooling and hot water), would still be discussed as part of the developer interview and reporting.

There may be benefit in including the CO_2 review on a case-by-case basis. For instance, it may be useful in older developers or where the developer wants to engage directly with residents about their energy consumption and opportunities for behaviour change.

7.2.3 Self-assessment tool

Throughout the project our intention has been to produce a self-assessment version of MDH-C that developers can use themselves to assess their plans or an existing development. We originally assumed this would be a self-guided application of the developer's interview questions including assigning scores for each outcome area and sub-category. However, feedback from the case study developers suggested that this may not be the best approach. It was felt that the value to a developer of a self-assessment is less about receiving a score and more about education. Additionally, it may be difficult for developers to objectively assign themselves scores, distracting from the fundamental learning opportunity provided by the tool.. The self-assessment tool has been modified so that a developer does not need to assign a score but can simply consider each question and determine their progress towards examples of best practice.

Other feedback around the self-assessment tool was that it might be useful as an entry point for a developer interested in better practice. A tool they could use at the early planning stage, or when their understanding of better practice is fairly low, with the opportunity to progress to a full assisted assessment further down the track.

Therefore, the self-assessment version has been modified in two ways. Firstly, more rationale and guidance has been provided for an entry-level user so that it has more of an educational function. Secondly, it has been modified so that a developer does not need to assign a score but can simply consider each question and determine their progress towards examples of best practice. Recommendations for improvement are implicit, as developers can see examples of better practice that they had not yet achieved or considered. Those seeking more advice and broader perspective (residents' views as well as an independent site review) might then pursue a fill assisted assessment.

8 The revised MDH assessment tool

The main revisions to the tool following the testing of MDH-C in case studies are outlined in section 7.2, above. Specifically, these changes are:

- Revisions to core outcomes, sub-categories and questions.
- Retaining the CO_2 review as part of the tool, but limiting its application to situations where its use is likely to result in savings in CO_2 emissions, such as in older buildings with less efficient lighting and appliances.
- Revising the self-assessment tool.

The figure below details the final MDH assessment tool framework and its core outcomes:

- Liveability
- Creating Community
- Connectivity
- Climate-Conscious Design
- Sustainable Operation and Behaviour

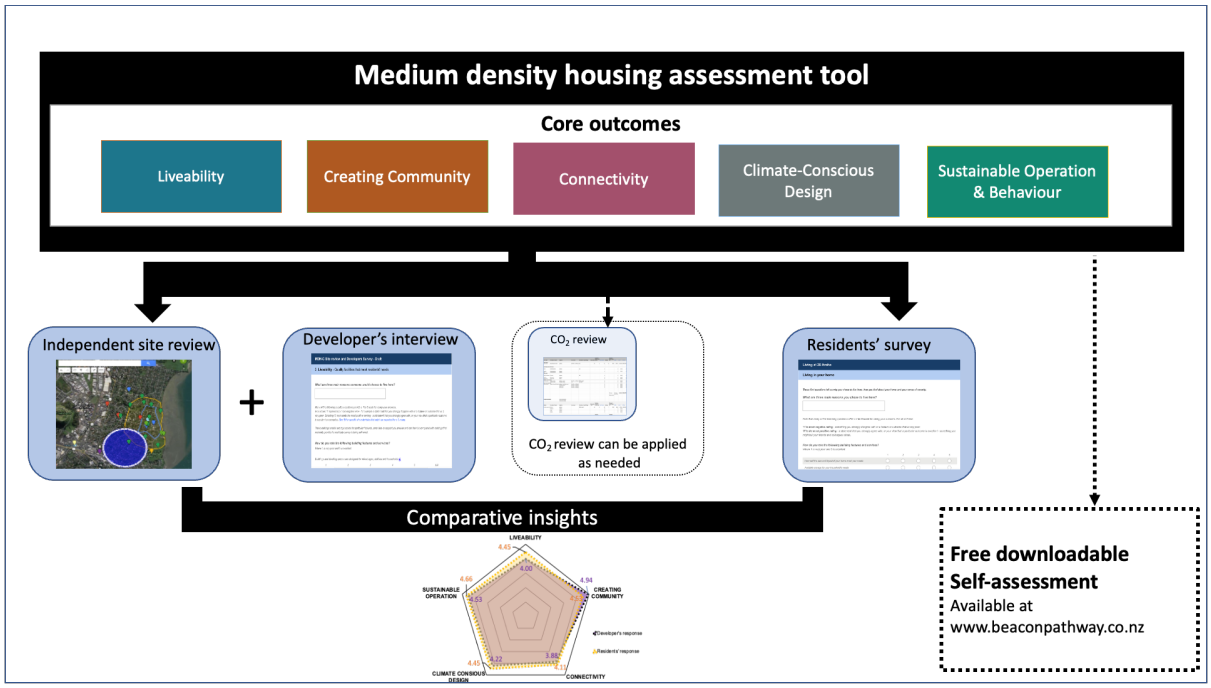


Figure 9: Finalised MDH assessment tool - framework and assessment methods

The following tables show the final version of MDH-C including each core outcome, their associated sub-categories and corresponding questions to be considered by Beacon during the site review, and by residents and by developers through the respective interviews. Scores are applied for each category from 1 (lowest) to 5 (highest) with 5 being considered an example of current best practice.

8.1 Liveability

Table 8: Liveability core outcome, sub-categories and developer and resident questions

Thoughtfully designed facilities that meet the everyday needs of residents.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Living in your home These first questions tell us why you chose to live here, how you feel about your home and your sense of security.	**Liveability** Features are rated from 1 to 5 where 1 determines that there was no consideration and 5 determines that the development provides exemplary features.
Choice	What are the three main reasons you chose to live here? [Text response]	What are three main reasons someone would choose to live here? [Text response]
	How do you rate the following building features and services:	How do you rate the following building features and services:
Dwelling design	How well the size and layout of your home meets your needs	Buildings and dwelling spaces are designed for mixed ages, abilities and households
Storage	Available storage for your household's needs	Residents are provided with appropriate storage
Noise control and privacy	Level of noise from other residents and the wider neighbourhood	Design reduces noise to acceptable levels between dwellings, public spaces and the wider neighbourhood
	Your ability to do your daily activities in your home and private outdoor spaces without feeling overlooked	Orientation of dwellings and private outdoor spaces means residents can go about their day to day living without the sense of being unduly overlooked
Sense of place	How well the building design adds to the local neighbourhood	Site design, frontages and artistic works create a cultural connection and a welcoming 'sense of place'
Care and maintenance	How well the building and the outside areas are maintained	Plans and monitoring to regularly maintain the buildings, outside spaces and service major appliances

Thoughtfully designed facilities that meet the everyday needs of residents.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	How do you rate the following:	How do you rate the following?
Security and emergency preparedness	Your feeling of safety in and around your property after dark	Security features, lighting, sensors, and active and passive surveillance provide a safe environment for all residents within their homes and throughout the site
	Safety of any children when playing around your property	Safe, quality play areas which are separate from vehicles and benefit from passive surveillance
	Your household's ability to respond to emergencies (e.g. long-term power cut)	An emergency preparedness plan gives procedural advice to residents with provision for back-up power and water should it be required
	How strongly do you agree or disagree with the following?	Thinking about tenure arrangements, how strongly do you agree or disagree with the following:
Affordability and tenure	This home is affordable for your household	Tenure options and supporting financial instruments provide residents with flexibility and security
	If renting: I am happy with the rental arrangement - otherwise leave blank	

8.2 Creating Community

Table 9: Creating Community core outcome, sub-categories and developer and resident questions

A design and management approach that fosters positive connections among residents.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Living together These questions tell us about your interaction with other residents and the kinds of things you would like to see that would improve your experience	**Creating Community** This section looks at actions that facilitate positive interactions between residents and create a sense of trust which is an essential foundation for resilient and sustainable communities
	How do you rate the following?	How do you rate the following amenities and actions to promote interaction?
Interaction by design	Any indoor or outdoor spaces where you can get together with other residents (e.g. common room, play areas, garden or sitting areas)	The provision of indoor and outdoor spaces for communal purposes that encourage interaction
Getting together	How would you describe your household's involvement with other residents for the following activities?	Actions are taken to encourage physical interaction between residents that build a trusting and resilient community
	Going for a walk or other leisure activities	
	Taking part in organised social events (e.g. BBQ)	
	Sharing a car ride (e.g. for shopping, work or other trips)	

A design and management approach that fosters positive connections among residents.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Lending or sharing things	
	Looking out for other residents' health or safety when they need support	
	Thinking about communication, how would you rate the following?	Thinking about communication, how would you rate the following?
Communication	The responsiveness of the property manager to any requests	Residents are regularly provided with information about the property, are actively included in decision making, while requests are monitored and dealt with
	Your ability to resolve issues with other residents	Conflict between residents is minimised or mediated
Satisfaction	Thinking about the community that lives here, how strongly do you agree that this is a great place to live?	Thinking about the community that lives here, how strongly do you agree that this is a great place to live?
	What changes would you like to see to help residents get together more? [OPEN QUESTION]	What changes could you make that would help residents get together more? [OPEN QUESTION]

8.3 Connectivity

Table 10: Connectivity core outcome, sub-categories and developer and resident questions

Quality infrastructure supports safe, sustainable and convenient access to important destinations.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Getting around This section tells us how you travel around and helps us understand what might make it easier	**Connectivity** This section can be undertaken alongside a desktop review that determines accessibility ratings for a range of commuting and other destinations by active and public transport options
	Tick all the ways members of your household travel to the following destinations. Note: Rating determined by incidences of active and public transport modes as a percentage of total number of all modes.	The extent of accessibility to key destinations is based on distance, infrastructure and services that enable safe travel on foot, with mobility aids, by cycle, or frequent public transport or by private vehicle. This can be completed either by an independent desktop review or by developers rating. How easy is it to travel to the following destinations by foot, mobility aid, cycle or public transport (approx. walkable distances are shown)
Travel and accessibility to key destinations	Work, study or training	Employment centres, study or training (walkable to approx. 2km)
	Schools or preschools	Schools or preschools (walkable between approx. 500m-2km depending on age range)
	Shops for food (e.g. supermarket or dairy)	Shops for food e.g. supermarket (1km) dairy (500m)
	Parks, open spaces or play areas	Parks, open spaces or children's play area (1km)
	Community and leisure facilities (e.g. library, place of worship, gym, sports)	Community or leisure facilities - library, place of worship, gym, sports (1km)

Quality infrastructure supports safe, sustainable and convenient access to important destinations.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Thinking about travelling from your home, how easy is it to do the following:	How do you rate any actions you undertake to support resident's travel:
Reducing travel by car	Travel on foot or with a mobility aid	Travel on foot or with a mobility aid
	Travel by cycle	Travel by bicycle
	Use public transport	Use public transport
	Reduce your car use (e.g. work or study from home or carpool with other residents)	Reduce their car use
	Thinking about safety, access and parking, how do you rate the following:	How do you rate the following safety, parking and wayfinding features?
Safety, wayfinding and travel management	Your feeling of safety from cars when you walk around your development	Design considerations reduce physical conflict between cars and other users within the site and at entry and exit points
	How easy it is for visitors, delivery services or emergency services to find your home	Wayfinding makes it easy for visitors, delivery or emergency services to identify the site and find resident dwellings
	Overall management of on-site parking	On-site parking is monitored and managed to maintain efficiency
	Are there any changes that would help you with your travel? [Text response]	Are the any changes you could make that would help residents with their travel? [Text response]

8.4 Climate-Conscious Design

Table 11: Climate-Conscious Design core outcome, sub-categories and developer and resident questions

Design minimises environmental impact, curbs embodied carbon and improves energy efficiency.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Building and the environment This section helps understand residents' views on environmentally friendly approaches to building	**Climate-Conscious design** Actions to reduce embodied carbon relate to all development stages from design, site management, material selection, construction and deconstruction
	How important is it for you live in a building that was designed:	How do you rate your efforts to reduce embodied carbon and mitigate the effects of climate change:
Habitat protection and climate consideration	To reduce its impact on the surrounding environment (e.g. habitats or waterways)	Actions to reduce levels of soil transfer and protect and enhance habitats and waterways during construction
	To cope with future changes in climate (e.g. reduce risk from flooding, fire or temperature changes)	Site selection aimed to avoid risks associated with a changing climate including flooding, coastal inundation, erosion, and wildfire
Low impact durable design	To be long lasting (e.g. 100 years or more)	Buildings are designed to last for 100 years, are easily repairable and can be easily deconstructed in future
		Buildings exhibit features that recognise the likely effects of a changing climate including periods of increased rain, drought, fire risk, temperature and wind variation
	How important is it for you live in a building that was designed:	How do you rate any efforts to build efficiently?

Design minimises environmental impact, curbs embodied carbon and improves energy efficiency.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
Efficient low-carbon building	Using sustainable, low-carbon materials and minimising construction waste	The development maximised building efficiency through a design that used less materials, adopting a modular scale with appropriate dwelling sizes
		Low-carbon materials were selected that considered the whole life cycle and demonstrated third party eco-labelling, responsible or local sourcing (e.g. FSC / NZ Environmental choice)
		Materials waste was minimised through accurate ordering, onsite storage that reduces degradation and effective separation of off-cuts for reuse or recycling
		Embodied carbon for this building has been calculated using an approved methodology and is shown to have been reduced where-ever possible
	Please add comments on any improvements you would like to see. [Text response]	Please add any comments or areas that could be improved for future projects. [Text response]

8.5 Sustainable Operation and Behaviour

Table 12: Sustainable Operation and Behaviour core outcome, sub-categories and developer and resident questions

Practical steps are taken to encourage low-carbon living and building operation.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Efficient use of resources This section is about energy, water use and household waste, and any actions that might increase efficiency and reduce costs.	**Sustainable operation** This section considers actions to reduce energy and water use through design and the efficient use of low energy appliances
	Thinking about living in your home, how easy is it for you to do the following:	How would you rate the following design activities that increase sustainable operation:
Operational efficiency by design	Get natural sunlight into your home	Building orientation and glazing enables appropriate levels of natural sunlight to public spaces and residences while actively reducing the need for daytime lighting
	Keep your home warm in winter	Building design reduces the need for heating through the use of glazing, insulation and other appropriate materials
	Keep your home cool in summer	Building design reduces the need for cooling by providing for cross ventilation with the supply of appropriate and movable shading over windows to prevent over-heating
	Ventilate your kitchen and bathroom and keep your home dry and free from mould	The above combination of heating and ventilation is designed to minimise moisture along with extraction from kitchens, bathrooms and laundries. Suitable areas are provided for drying clothes outside
	Dry your clothes outside	

Practical steps are taken to encourage low-carbon living and building operation.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
		Thinking about energy supply and management, how would you rate the following:
Low-carbon energy supply and management	How important is it that energy in this building is used efficiently and comes from renewable sources?	The energy use for the building's operation is provided through localised generation and / or renewable grid supply that also enhances resilience
		Energy use and associated CO_2 is monitored with targets to continually improve efficiency, reduce emissions or offset emissions, and these are reported to residents
	How often do you do the following:	Please rate any of the following efforts you have taken to maximise energy efficiency:
Maximising efficient energy use	Use energy efficiently for lighting, heating, cooling and appliances	Design considerations reduce the need to provide and maintain multiple appliances where possible (e.g. individual washing machines, dryers or heat pumps in each unit)
		Appliances for lighting, heating, cooling, and ventilation have maximum efficiency ratings with appropriate controls, timers and detectors to ensure they are only used when necessary
	Reduce hot water use (e.g. shorter shower times)	Water is efficiently heated at low cost using a centralised system through solar or low-carbon energy
Supporting sustainable behaviours	Reduce cold water use (e.g. turn tap off when cleaning teeth)	Rainwater harvesting and grey water recycling reduces the need for mains supply
		Efficient water use is supported through low flow devices, water efficient appliances and advice to residents
	Recycle (e.g. glass, plastics and cardboard)	

Practical steps are taken to encourage low-carbon living and building operation.		
CATEGORY	**RESIDENTS SURVEY**	**DEVELOPER REVIEW**
	Compost or use food scraps collection	Waste minimisation is encouraged through the provision of information, appropriate placement and active management of waste, recycling and composting facilities, and continual engagement
	Garden or grow your own food	Landscaping enhances biodiversity while interested residents are supported to grow food in a well-maintained garden area
	How would you rate any information you have been given on managing your home more sustainably	Information on sustainable living is given to residents, and this is actively promoted
	Please add any comments on sustainability improvements you would like to see [Text response]	Please add any comments on sustainability improvements you could introduce [Text response]

8.6 A self-assessment version of MDH-C

We have developed a free, downloadable, simplified version of MDH-C for use by those who want to review a development or plans against its core outcomes. This self-assessment tool is based on the developer questions and provides a simple checklist of things to consider, with examples of better practice. While it can be used in a range of situations it is expected to be useful as an entry point for a developer interested in better practice; a tool they could use at the outset of a development, or when their understanding of better practice is fairly low. It could be particularly useful at the early design stage, with a full assessment being valuable once the development is at a detailed design stage and then again when the development is occupied (including a site review and residents' survey).

More rationale and guidance has been provided for an entry-level user, so that it has more of an educational function. Recommendations for improvement are inferred as developers can see examples of better practice that they may not yet have achieved or considered.

The tables below show the full text of each section of the self-assessment tool. A full copy of the self-assessment tool is available on Beacon's webpage. Alongside the questions below, the tool includes a space for any notes that a developer may want to make.

8.6.1 Liveability

Thoughtfully designed facilities that meet the everyday needs of residents.

This section outlines the facilities and services that contribute to affordable, quality accommodation and public spaces for residents. These include essentials such as sufficient storage, quiet and private living spaces, well-maintained buildings and surroundings, and a safe, secure environment – including for children to play.

Beyond the basics, other factors are increasingly recognised as crucial for long-term liveability, including design choices that enhance residents' satisfaction and encourage a sense of belonging – creating a 'sense of place'. These can be achieved through linking to local history, integrating green spaces, or design elements that complement the neighbourhood's character and architectural style.

Table 13: Liveability core outcome, characteristics and examples of better practice

Characteristic	Summary	Examples of better practice
Dwelling design	Buildings and dwellings are designed for mixed ages, abilities and households.	- Adopt universal design principles such as those outlined by Lifemark® for some units. - Consider the adaptability of the homes for future use e.g. bracing in bathroom walls to enable the installation of grabrails. - Include accessibility feature such as ramps, seating, handrails and good lighting in public areas. - Consider child safety throughout the site. - Provide play areas.
Storage	Residents have appropriate storage.	- Provide internal storage for clothes, linen, food, cleaning supplies, pushchairs/mobility aids, toys etc. - Incorporate storage for lifestyle items like bikes and surfboards. - Design shared storage for larger or communal items like lawn mowers and garden tools.
Noise control	Design keeps noise at acceptable levels between homes, shared spaces and the wider neighbourhood.	- Select materials and orientate dwellings to reduce noise amongst residences: - between floors - between walls - through glazing. - Orientate communal areas away from residences. - Reduce noise from the surrounding neighbourhood though material selection and dwelling orientation.
Privacy	Dwellings and private outdoor spaces are designed to allow residents to go about their daily lives without being unduly overlooked.	- Design to ensure a sense of privacy within residences. - Orientate outdoor private spaces to be out of 'line of sight' from the public and neighbours. - Enhance privacy through adjustable shielding where possible. - Provide window coverings.
Sense of place	The site design, frontages and artistic works create a cultural connection and a welcoming 'sense of place'.	- Incorporate connections to local history through design, artworks or information panels. - Consider impacts of the development on mana whenua and engage as appropriate. - Consider impacts of the development on the local community and engage as appropriate. - Ensure the building design features complement and enhance the surrounding neighbourhood.

Characteristic	Summary	Examples of better practice
Care and maintenance	Plans and monitoring are in place to regularly maintain buildings, outside spaces and service major appliances.	- Establish maintenance and cleaning plans and regularly monitor. - Maintain and regularly clean public areas. - Respond to residents' requests regarding maintenance and cleaning. - Regularly service and clean appliances in residences, such as heat pumps. - Provide residents with user manuals and offer advice on maintaining appliances.
Security	Security features including lighting, and active and passive surveillance ensure a safe environment for all residents, both within their homes and throughout the site.	- Complete a Crime Prevention Through Environmental Design (CPTED) assessment. - Install lighting with sensors, appropriate for the site. - Design to minimise 'hidden spaces' around the site. - Design for passive surveillance to offer residents a sense of security. - Consider security cameras for additional monitoring at key access points.
	Safe, high-quality play areas are designed to be separate from vehicles. Passive surveillance gives added security.	- Design the site to offer safe play places that are separate from parking and driveways. - Enhance safety for children onsite by designing for passive surveillance.
Emergency preparedness and resilience	An emergency preparedness plan gives procedural advice to residents. Backup systems e.g. onsite power generation and potable water storage are provided.	- Establish plans to enhance and support residents' resilience during emergencies (e.g. flood, fires, power outages). - Develop emergency preparedness plans and share with residents. - Ensure onsite power generation is available in case of power outages. - Store potable water onsite for emergency use. - Adopt strategies to encourage community interaction and mutual support during emergencies.
Affordability and tenure	Tenure options and supporting financial instruments offer residents both flexibility and security.	- Offer both short-term and long-term tenancies. - Provide tenure progression options, such as rent-to-own.

8.6.2 Creating Community

A design and management approach that fosters positive connections among residents.

Strong social connections are a hallmark of thriving MDH developments. Good design can encourage daily social exchanges, fostering friendships that evolve into close-knit communities. These connections create opportunities for residents to boost their economic resilience by pooling resources (e.g. car sharing) and collectively addressing future challenges such as energy price rises, or economic and environmental changes.

Shared indoor and outdoor spaces offer opportunities for residents to connect, whether through shared meals or as children from neighbouring homes play. Additionally, well-designed services and facilities can promote social bonds, support health and fitness, and the efficient sharing of resources and transport. Together, these elements enrich residents' quality of life, offer potential cost savings, and lay the groundwork for long-term community development.

Table 14: Creating Community core outcome, characteristics and examples of better practice

Characteristic	Summary	Examples of better practice
Interaction by design	The development features shared indoor and outdoor areas that encourage community interaction.	- Play areas for children. - Communal gardening spaces. - Areas and facilities for shared meals e.g. barbeques. - A common room for meeting or socialising. - Shared laundry facilities.

Getting together	Steps are taken to encourage face-to-face interaction among residents, helping to create a trusting and resilient community.	- Establish services and amenities to promote interaction, for example:
		  - a residents' notice board.
		  - tool, appliance and toy exchanges.
		  - facilitated clubs e.g. walking, book, gardening.
		  - organised carpooling.
		  - community events for residents.

Communication	Residents are regularly updated about the property and actively involved in decision-making. Residents' requests are tracked and swiftly actioned.	- There are scheduled meetings for residents. - Regular newsletters and updates keep residents informed. - Encourage active participation across the community. - Monitor residents' requests and report their progress and completion.
	Conflict between residents is minimised or mediated when necessary.	- Provide residents with a point of contact to privately raise concerns. - Offer mediation when needed.

Satisfaction	Residents consider your development is a great place to live.	- Regularly invite residents to share their feedback.

8.6.3 Connectivity

Quality infrastructure supports safe, sustainable and convenient access to important destinations.

Developments thrive when they are close to key destinations – employment centres, schools, shops, educational institutions, and community and leisure facilities.

Developers can also enhance connectivity by incorporating design features that help people get around on foot or by mobility aid, by bike and by public transport. These choices not only improve health and well-being but cut reliance on fossil fuels and reduce associated carbon dioxide emissions.

Table 15: Connectivity core outcome, characteristics and examples of better practice

Characteristic	Characteristic	Examples of better practice

Travel and accessibility	Key destinations can be easily accessed without a car – by foot, mobility aid, cycle or public transport.	- Walkable distances to key destinations are shown below:
		  - employment centres, study or training facilities within 2km.
		  - schools or preschools within 500m-2km depending on age.
		  - supermarket or dairy within 1km.
		  - parks, open spaces or play areas within 1km.
		  - community or leisure facilities (e.g. library, place of worship, gym, sports) within 1km.

Reducing travel by car	Residents are supported to travel on foot or with a mobility aid.	- Safe, well-designed footpaths and ramps ensure easy access both within the development and to nearby facilities and services. - Provide storage spaces for scooters, pushchairs and other mobility aids. - Advocate for improved safety and accessibility features in the surrounding neighbourhood, such as good lighting, clear and accessible paths and safe pedestrian crossings.
	Cycling within the community is supported. Cycling facilities are provided.	- Secure bike storage. - Bike parking for visitors. - Advocate for safe, off-road routes to key destinations. - Provide communal bikes.
	Public transport is encouraged.	- Position the development near public transport hubs. - Provide links to online journey planners and hard copy timetables where appropriate. - Offer subsidised public transport passes. - Advocate for new services or increased service frequency to better serve residents.

Characteristic	Characteristic	Examples of better practice

	Other ways to support residents to reduce travel by car are explored and implemented as appropriate.	- Examples include:
		  - coordinated shopping deliveries to reduce individual trips.
		  - facilitated carpooling or shared vehicle arrangements.
		  - encouraging working locally or from home.
		  - setting active car-use reduction targets.
		  - setting up residents' groups e.g. biking group or walking club.

Safety	Design minimises the risk of conflict between vehicles and pedestrians, cyclists and other users within the development and at entry/exit points.	- Clearly delineate accessways for pedestrians. - Clearly mark parking bays. - Ensure adequate lighting around parking areas and at exit/entry points. - Implement speed controls. - Ensure vehicles have line-of-sight, particularly when reversing.
Wayfinding	Wayfinding makes it easy for visitors, delivery or emergency services to identify the site and find resident dwellings.	- Make street address and site name clearly visible for easy identification. - Display a site plan for both pedestrians and drivers. - Number units with an identifiable and logical system. - Provide adequate space for trade or emergency vehicles to turn around safely.
Parking management	On-site parking is actively monitored and managed to ensure efficiency.	- Provide clear parking guidelines for residents. - Dedicate access and parking provisions for mobility vehicle users. - Implement an active car parking reduction strategy to free up space for other potential uses.

8.6.4 Climate-Conscious Design

Design minimises environmental impact, curbs embodied carbon and improves energy efficiency.

Building for the future demands a climate-conscious approach that not only reduces environmental impact, but also mitigates risks posed by climate change, such as from flooding, inundation, erosion, and wildfires. Climate-conscious design prioritises reducing embodied carbon and increasing efficiency. It includes site selection and management, material choices, and all stages of construction and deconstruction. This approach also includes reducing construction waste through accurate ordering and recycling of remaining materials.

More residents now are now expecting to live in homes built with low embodied carbon, using materials that are efficiently produced, long-lasting and preferably locally sourced.

Table 16: Climate-Conscious Design core outcome, characteristics and examples of better practice

Characteristic	Summary	Examples of better practice
Habitat protection and climate consideration	Action is taken to protect and enhance habitats and waterways during construction. Soil transfer is minimised.	- Establish plans to minimise soil transfer. - Protect and monitor waterway quality where necessary. - Implement habitat enhancement plans.
	Site selection aims to avoid risks associated with a changing climate, including flooding, coastal inundation, erosion, and wildfires.	- Use climate mapping to inform site selection. - Assess site risks and position the development to avoid the following: - flooding - coastal inundation - erosion - wildfires.
Low impact durable design	Buildings are designed to last for 100 years, are easily repairable and can be easily deconstructed in future.	- Design the building to last for at least 100 years. - Use building materials that are easily sourced and repairable. - Design so utilities are easily accessible, with components that can be repaired or replaced. - Design and construct the building so it can be easily deconstructed so materials can be reused.
	Buildings are designed for likely climate change impacts including increased rain, drought, fire risk, temperature	- Design gutters and downpipes to handle extreme rainfall, events. - Avoid internal gutters. - Design parking areas that are permeable and reduce stormwater runoff. - Use light and heat-resistant paint on external surfaces.

Characteristic	Summary	Examples of better practice
	fluctuations, and wind variation.	- Use weather-resistant materials to avoid warping or cracking due to temperature variations. - Design gardens to be drought-resistant.
Maximising building efficiency	The development maximises building efficiency by using fewer materials and adopting a modular design with appropriately dwelling sizes.	- Demonstrate efficient use of materials in the design. - Reduce the need for larger dwelling sizes through provision of shared amenities (e.g. laundry and storage). - Rely on modular dimensions, aligned with standard material sizes to reduce waste from off-cuts. - Design dwelling sizes so they are proportionate to the intended number of residents.
Low-carbon material selection and efficient use	Low-carbon materials are selected, considering the whole life cycle, third-party eco-labels or certifications, and responsible or local sourcing (e.g. FSC / NZ Environmental choice).	- Source materials locally where possible. - Demonstrate eco-responsible sourcing. - Obtain external verification of material use (selection or lifecycle analysis).
Minimisation of waste	Materials waste is minimised through accurate ordering, proper onsite storage to prevent degradation, and effective separation of off-cuts for reuse or recycling.	- Adopt construction approaches that ensure: - accurate ordering of materials - waste is reduced - waste separation and recycling of remaining building materials. - Provide domestic recycling bins for workers on the construction site.
Calculating and mitigating embodied carbon	Embodied carbon for this building is calculated using an approved methodology and has been reduced where-ever possible.	- Demonstrate the application of a verified carbon reduction methodology. - Document how recommendations from the carbon assessment were implemented to reduce embodied carbon through modified building design, materials selection and optimised material quantities.

8.6.5 Sustainable Operation and Behaviour

Practical steps are taken to encourage low-carbon living and building operation.

Significant reductions in carbon emissions come from efficient energy use. This begins with design choices that minimise the energy required to light, heat and cool a building, along with sustainable energy delivery. This can include onsite renewable energy generation or purchasing renewable energy from the national grid. Providing energy-efficient appliances and promoting sustainable behaviour is part of a broader strategy to reduce residents' environmental impact over time.

Table 17: Sustainable Operation and Behaviour core outcome, characteristics and examples of better practice

Characteristic	Summary	Examples of better practice
Lighting	Building orientation and glazing design allows adequate levels of natural light into residential and public spaces, reducing the need for artificial lighting during the day.	- Reduce reliance on artificial lighting through careful building orientation and design. - Position glazing to maximise natural light during the day. - Conduct a lighting assessment and implement the recommendations.
Heating and cooling	The building's design minimises the need for heating through use of glazing, insulation and thermally efficient materials.	- Use thermal modelling to inform the design. - Orientate the building to optimise solar gain and minimise over-heating. - Install thermally broken and double- or triple-glazed windows. - Optimise window size and placement for solar gain and privacy and to avoid overheating. - Install insulation to best practice standards. - Supply window coverings to effectively retain heat. - Draught-proof windows and doors.
	To reduce cooling needs, the design allows for natural cross ventilation. Moveable window shading prevents overheating.	- Optimise natural cross ventilation through well-positioned windows. - Provide movable shading for outdoor areas and glazing to prevent overheating. - Provide additional shading with appropriate window coverings when needed.

Characteristic	Summary	Examples of better practice
Moisture control	Moisture in the home is minimised by providing appropriate heating and ventilation (including externally vented extraction fans) and suitable outdoor clothes drying areas	- Install vented extraction systems to control moisture in kitchens, bathrooms and laundries. - Provide suitable outdoor areas for drying clothes. - Offer residents practical advice on reducing moisture in their homes. - Monitor properties for mould and take swift action to remedy.
Low carbon energy supply and management	Energy for the building's operation is sourced through local generation or renewable grid supply.	- Generate power onsite using photovoltaic panels or other renewable sources. - Rely on grid supplied energy from renewable sources. - Establish a resilience plan to ensure backup power during outages.
	Energy use and associated CO_2 are monitored with targets to continually improve efficiency, cut emissions, or offset emissions where needed. Residents are kept informed of actions and results.	- Track energy and CO_2 in public areas. - Set and monitor emission reduction targets. - Establish offsetting strategies for non-renewable energy use. - Provide regular reports to residents, alongside tips for improving energy efficiency.
Appliances	Design reduces the need for multiple appliances where possible e.g. individual washing machines or heat pumps and encourages shared, centralised systems.	- Design centralised systems for heating, cooling and ventilation. - Reduce the need for multiple individual appliances through provision of shared facilities such as a laundry.
	All appliances for lighting, heating, cooling, and ventilation are highly efficient, equipped with smart controls, timers and detectors to optimise usage.	- Install efficient, maximum star-rated appliances e.g. dishwashers, washers, dryers, fridges, heat pumps, cookers. - Enable off-peak energy use through installation of controllers and timers. - Install lighting with daylight and presence detectors to ensure lighting is only used when necessary.

Characteristic	Summary	Examples of better practice
Water heating	Water is heated efficiently and at low cost using centralised systems using solar or low-carbon energy.	- Provide solar-powered water heating wherever possible. - Minimise need for individual hot water heating units through provision of a centralised hot water system. - Install low-flow shower heads in every home. - Provide for backup water heating in case of power outages.
Water supply and use	Rainwater harvesting and greywater recycling reduce reliance on reticulated supply.	- Capture rainwater and use wherever possible. - Install greywater systems to recycle water from laundry and showers. - Store water for emergencies as part of resilience plans.
	Efficient water use is supported through low-flow devices, water-efficient appliances and guidance to residents.	- Monitor water usage, and plan to reduce consumption over time. - Install washing machines and dishwashers with maximum water efficiency rating - Fit low-flow systems to taps and showerheads. - Offer residents practical advice on how to conserve water.
Waste	Waste minimisation is encouraged through the provision of clear information, and appropriate placement and active management of waste, recycling and composting facilities.	- Provide easily accessible waste and recycling facilities. - Provide for food waste management via council food waste collection and/or provide on-site composting / worm farm. - Offer residents information on waste reduction. - Monitor waste and set targets for reduction.
Sustainable food	Landscaping enhances biodiversity, while interested residents are supported to grow food in a well-maintained garden area.	- Enhance biodiversity through landscaping that uses native plants and habitat creation. - Plant fruit trees and herbs on site so they are accessible. - Provide a communal garden or offer the option to establish one if residents show an interest.
Information	Information on sustainable living is shared with residents and actively promoted through ongoing engagement.	- Provide residents with A Home User or Residents' Manual with information on appliances, building features and tips for their efficient use. - Offer face-to-face instructions to help residents understand how to use systems and controls efficiently.

8.6.6 Distributing the self-assessment tool

The main approach to distributing the self-assessment tool will be via Beacon Pathway's website. This will host the excel workbook which will be freely available to download. It is intended that information about the self-assessment tool will be provided alongside public facing versions of the case studies, details on the 'assisted' version of the tool and contacts for more information.

Other methods to promote and distribute the self-assessment tool include the Beacon Pathway website and newsletter as well as other stakeholder forums and associated conferences.

9 Stakeholder engagement and knowledge transfer

Beacon has engaged with stakeholders throughout the project in order to:

- Understand the operating environment and guide the direction of the project so that it remains relevant to the sector and the community.
- Access expert opinion and other feedback, as appropriate.
- Create understanding and awareness of MDH-C, either as a case study in the project or once the tool is finalised.

Engagement occurred at a variety of levels through the project.

9.1 Engagement with previous users of the tool

Beacon contacted past users of the tool to obtain feedback on the value of the tool and aspects to consider as part of the tool's further development. CORT Community Housing responded to the opportunity and the CORT CEO, Head of Operations and Development Manager met with Beacon in June 2022. CORT provided detailed feedback which informed work to develop the tool. Key findings were:

- The existing tool worked for them, and they did not want to change too much.
- CORT were interested in the carbon needed to build and what they could change. They identified this as an area that they wanted to invest more in, acknowledging that they had competing foci in terms of time and cost.
- CORT were interested in detailed feedback as well as high level feedback. The detail often impacts on the liveability of a home.

Kāinga Ora suggested a meeting with a broad range of staff to look at the new tool in more detail. This meeting was held in October 2022, following the revisions to the tool for testing in the case studies. Other organisations that had been involved in the development of MDH-1 or had previously applied MDH-1 in their developments either provided high-level feedback, such as ensuring that the use of the tool was not cost prohibitive, or did not take up the opportunity to provide feedback.

9.2 Engagement with Kāinga Ora - Homes and Communities

Kāinga Ora is the largest landlord in Aotearoa and a significant developer of MDH. Beacon has worked with them since the inception of this project, and previously, as a user of the tool. Kāinga Ora supported Beacon's proposal to BRANZ in 2021. In October 2022 Beacon held a face-to-face meeting with a cross-section of Kāinga Ora staff interested in good outcomes from MDH, post-occupancy evaluation, and/or carbon. A number of participants from outside Auckland joined the meeting remotely. Attendees included staff ranging from on-the-ground tenancy managers to senior departmental managers.

The purpose of the session was to provide Kāinga Ora with an overview of the tool and to review the spreadsheet details. In addition, the meeting was to get feedback on the relevance of MDH-C to their planning and whether a Kāinga Ora development could be included as a case study.

A copy of the draft tool was supplied to Kāinga Ora and a potential case study development was identified at the beginning of 2023. Given that this development was not going to be occupied until late 2023, it was not able to be used as a case study in the research. However, Kāinga Ora commissioned an assessment of the development once residents had lived there through a summer and a winter. This assessment was undertaken in mid-2024, and while the case study is not a deliverable for this research, insights from the assessment have informed the final revisions of the tool.

9.3 Engagement with experts

During the project, we engaged with a number of central and local government entities to ensure the project was aligned with their work programmes. In some cases, this project informed their work. For example, we worked with Ministry for the Environment to provide guidance as part of the development of the National MDH Guide so that it could provide more detail on carbon.

9.4 Engagement through case studies

The case studies were designed to engage the developer / property managers with the tool and to receive feedback on its content and usefulness. We achieved this by:

- Providing the developer/property manager with the complete excel spreadsheet so they could understand the questions and how the tool worked.
- Sharing the rationale for the content of the tool and why concepts were included.
- Requesting feedback prior to the tool's application, during application and following application.

Through the case studies Beacon was also introduced to other experts, including architectural designers and developers. Discussions with these parties also informed the development of MDH-C. A follow-up review and feedback session with the case study developers also informed the final iteration of the published tool.

9.5 Engagement with broader stakeholders

Beacon has also shared information about the research with sector stakeholders throughout the project. This has included:

- Articles in Beacon's '*Facing*' newsletter and Beacon's webpages.
- Presentations, including to stakeholders as Beacon's "Turning Research into Action" symposium held in Wellington in December 2023 and Beacon's Annual General Meetings

Further knowledge transfer is underway, particularly in terms of engaging developers and property managers in the use of MDH-C. Beacon has submitted a proposal to present at the Community Housing Aotearoa conference in November 2024 and is available to discuss the tool with any interested groups or individuals.

10 Summary and conclusions

Through this research we have revised and expanded our Medium Density Housing Assessment Tool. Operational and embodied carbon from the construction and operation of MDH are now integral to the tool's core outcomes and its assessment methods. The tool reflects national and international best practice for the development of high-quality, low-carbon MDH.

Using case studies and engagement with the sector as our research methods we made a number of amendments to the version of the tool that we tested. This includes:

- Minor amendments to the wording to the titles and within the core outcomes and their sub-categories.
- The CO_2 review will not form one of the tool's key assessment methods, although it may be used on a case-by-case basis and in older development.

We also revised our approach to developing a publicly-available self-assessment version of the tool. The final version of this, which will be available for free download from Beacon's website, guides a user through the core outcomes and their component parts encouraging them to consider the extent to which their development achieves examples of best practice. However, the self-assessment version does not include scores - it became clear that self-assigned scores in isolation were of little value to a lay user and may distract from the educational opportunity inherent in a publicly available version.

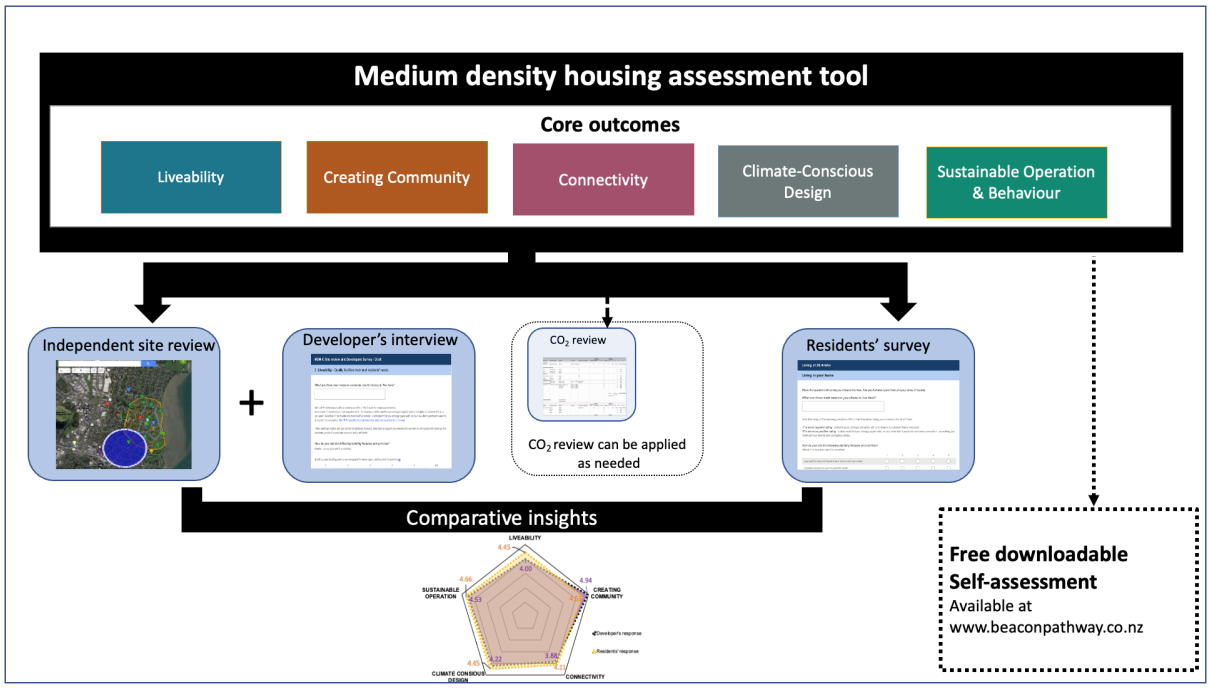


Figure 10: Finalised MDH assessment tool - framework and assessment methods

Like its predecessor, the tool is unique in bringing residents' voices into an assessment of MDH developments, enabling comparison between what the developer believes they have achieved, with what the residents consider successful. The case studies showed that the tool can be applied to this end

across different MDH market segments. In addition, the case studies highlighted that the framework also provides the basis for engagement and education of different parties around the various aspects of developing and living in high-quality, low-carbon MDH.

MDH continues to play an important role in responding to the pressing need for more affordable, well-performing, homes in Aotearoa. Equally, and despite a changing political climate domestically, Aotearoa must continue to work towards meeting its international climate change obligations and adapt to the impossible-to-ignore effects of climate change. Beacon Pathway's revised and expanded MDH assessment tool is well-positioned to play a role in enabling MDH developers to respond to these challenges.

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Appendix One - Regulatory and policy context for MDH-C

Since the development of MDH-1, there has been an increasing focus on the contribution of housing to greenhouse gas emissions. This has come about alongside Aotearoa New Zealand's commitment to the Paris Agreement, national and regional climate emergency declarations, legislative changes and the introduction of specific strategies and action plans which guide the design, placement, construction and operation of buildings.

As part of the scoping work for MDH-C we undertook a review of the regulatory and policy context for MDH in Aotearoa New Zealand to ensure that the tool reflected, and supported, that context. The scope of the review was legislative and policy setting relevant to MDH and the mitigation of, and adaptation to, climate change, including:

- Embodied carbon emissions (associated with building materials, construction, transportation, and eventual deconstruction of a building).
- Operational carbon (carbon emitted through the use of energy and water to operate and live in the building).
- Relevant aspects of land use planning.

This review was originally undertaken in May 2022. We note that a number of significant regulatory and policy changes have been signalled, or have occurred, since the change of government in 2023. The text below notes relevant changes, where information is publicly available.

Climate Change Response Act 2002

The Climate Change Response Act 2002 was amended through the Climate Change Response (Zero Carbon) Amendment Act 2019 to provide a framework for Aotearoa New Zealand to set climate change targets and identify and respond to climate risks and impacts. The principal elements of this framework are:

- The establishment a Climate Change Commission to provide advice to the Government on mitigating climate change and to monitor and review the Government's progress towards its emissions reduction and adaptation goals.
- Requirements for the Climate Change Commission to prepare of a National Climate Change Risk Assessment (NCCRA) every six years and to make recommendations to government on emissions budgets.

The first NCCRA for Aotearoa New Zealand, *Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa (2020),* identifies the following built environment risks as extreme and of high urgency. They sit amongst the ten most significant climate change risks.

- Risks to buildings due to extreme weather events, drought, increased fire weather and ongoing sea-level rise.
- Risk to potable water supplies (availability and quality) due to changes in rainfall, temperature, drought, extreme weather events and ongoing sea-level rise.

In response to this advice the government has developed the first National Emissions Reduction Plan (ERP) and National Adaptation Plan (NAP).

Te hau mārohi ki anamata - Towards a productive, sustainable and inclusive economy: Aotearoa New Zealand's first emissions reduction plan (2022) lays out the following key actions for the building and construction sector:

- Reduce embodied carbon by supporting innovation and regulating to promote the use of low emissions building design and materials.
- Promote good examples, provide incentives to support the use of low emissions practices.
- Amend the Building Code and measure energy performance to ensure buildings are designed, and retrofitted, to use less energy for heating and cooling.
- Shift energy use from fossil fuels by developing a gas transition plan and understand the impacts of transition for households and communities.
- Establish foundations for future emissions reduction by improving emissions data for buildings and materials, building relationships with Māori, and progressing behaviour change and workforce transition programmes.

The government consulted on the second Emissions Reduction Plan between July and August, 2024 and is currently considering submissions. The role of the building and construction sector in emissions reduction was not considered in the consultation draft. Consequently, there were no corresponding policies or objectives for the sector. It is currently unclear what impact this will have on policies and programmes of work included below that were driven by the first ERP.

The first National Adaptation Plan, *Urutau, ka taurikura: Kia tū pakari a Aotearoa i ngā huringa āhuarangi (2022)* identifies the following critical actions for homes, buildings and places:

- Embed adaptation in funding models for housing and urban development, including Māori housing.
- Establish an initiative for resilient public housing.
- Reduce and manage the impacts of climate hazards on homes and buildings.
- Support kaitiaki communities to adapt and conserve taonga/cultural assets.

The Climate Change Commission published its first reports on the government's progress against the National Adaptation Plan and Emissions Reduction Plan in July 2024.

Building for Climate Change Programme (MBIE)

MBIE's Building for Climate Change Programme (BfCC), is responsible for leading the building and construction sector's response to climate change, including delivering actions in the first ERP and NAP. BfCC is working on a range of initiatives to reduce emissions and increase the climate resilience of our build environment:

- Reducing whole-of-life embodied carbon emissions.
- Transforming operational efficiency.
- Supporting adaptation and building climate resilience.

As part of this programme, MBIE has published technical methodologies to support assessments of embodied carbon and operational efficiency in new buildings.

- *Whole-of-Life Embodied Carbon Emissions Reduction Framework (2020*) provides the framework for government to introduce new requirements to measure, and over time, put a cap on the whole-of-life embodied carbon emissions of new buildings.

- *Whole-of-Life Embodied Carbon Assessment: Technical Methodology (2022)* provides a technical methodology for assessing the whole-of-life embodied carbon of buildings in Aotearoa New Zealand to improve the consistency of assessments currently being undertaken and to introduce embodied carbon assessments to those who may be less familiar with the concepts.
- *Transforming Operational Efficiency (2020)* proposed required caps and levels of efficiency for new buildings with a focus on energy and water use and minimum indoor environmental quality measures.
- *Transforming Operational Efficiency Framework: Technical Methodology (2021)* a targeted consultation was released in late 2021.

There is currently no requirement for the use of these methodologies, however MBIE has signalled that they will underpin proposed future requirements in the Building Code for whole-of-life embodied carbon and operational efficiency assessments.

The Building for Climate Change programme is also responsible for co-leading Chapter 7 of the NAP with Ministry of Housing and Urban Development and Ministry for the Environment. MBIE is responsible for delivering the following four actions:

- Action 3.25: Design Methodology for risk assessments of public buildings (2024-2026).
- Action 5.7: Reduce and manage the impacts of climate hazards on homes and buildings (2022-2026).
- Action 7.4: Update regulatory requirements to ensure buildings are designed, and constructed to withstand more extreme climate hazards (2024-2028).
- Manage potential impacts of adaptation related to regulatory change (2026-2028).

There has been no public announcement whether work signalled under BfCC will continue under the existing government.

Changes to the New Zealand Building Act 2004 and the Building Code

The New Zealand Building Code is contained in regulations under the Building Act 2004, and all building work in Aotearoa New Zealand must comply with it. Significant changes were signalled to the Building Act over the term of the last government, including changes to the Building Act to:

- Make it mandatory for new and existing public, industrial and large-scale residential buildings (such as multi-storey apartment buildings) to hold energy performance ratings.
- Require those intending to undertake certain building or demolition work to have a waste minimisation plan.
- Change the principles and purposes of the Building Act, to clarify that climate change is a key consideration.

Further changes to the Building Code were expected over the coming decade as part of the BfCC programme. It is now unclear whether this work will be progressed. It is also noteworthy that the Minister for Building and Construction, Chris Penk, has signalled his desire to reduce the energy efficiency standards in clause H1 of the Building Code to pre-2022 levels.

Housing and Urban Development

Since the development of MDH-1 government has introduced a number of significant strategies and policies designed to enable good quality urban development. These support a greater focus on lower carbon medium density housing.

Government Policy Statement on Housing and Urban Development (GPS-HUD)

The Government Policy Statement on Housing and Urban Development (GPS-HUD) is a high-level multi-decade strategy for housing and urban development in Aotearoa New Zealand. It sets the government's vision for housing and urban development, and it is a requirement of the Kāinga Ora – Homes and Communities Act 2019. The GPS-HUD must be given effect by Kāinga Ora, the government's public housing provider and urban development agency. One of its goals is to reduce carbon emissions and support communities to adapt to the effects of climate change. Its four main goals are:

- **Thriving and resilient communities -** The places where people live are accessible and connected to employment, education, social and cultural opportunities. They grow and change well within environmental limits, support our culture and heritage and are resilient.
- **Well-being through housing** - Everyone lives in a home, whether it's rented or owned, that is warm, dry, safe, stable and affordable, with access to the support they need to live healthy, successful lives.
- **Māori housing through partnership** - Māori and the Crown work together in partnership so all whānau have safe, healthy, affordable and stable homes. Māori housing solutions are led by Māori and are delivered locally. Māori can use their own assets and whenua Māori to invest in and support housing solutions.
- **An adaptive and responsive system** - Land-use change, infrastructure and housing supply is responsive to demand, well planned and well regulated.

MAIHI Ka Ora – The National Māori Housing Strategy 2021-2051

MAIHI Ka Ora (the National Māori Housing Strategy) was developed alongside the GPS-HUD so they have cohesive and consistent approaches, actions, and goals and can be implemented together. The vision of MAIHI Ka Ora is that all whānau have safe, healthy, affordable homes with secure tenure, across the Māori housing continuum. One of its priorities is Māori housing sustainability, which aims to ensure new houses are more sustainable and to explore self-sustaining technologies for Māori housing that will help drive emissions reductions.

National Policy Statement on Urban Development (NPS-UD)

National Policy Statements provide national direction on significant matters under the Resource Management Act 1991 that councils must give effect to. The *National Policy Statement on Urban Development (NPS-UD) (2020*) sets out the objectives and policies for planning well-functioning urban environments that meet the changing needs of diverse communities and removes some of the barriers to development to allow growth 'up' and 'out' in locations that have good access to existing services, public transport networks, and infrastructure. It also includes emissions-reduction objectives that local authorities must give effect to, including ensuring Aotearoa New Zealand's urban environments support reductions in greenhouse gas emissions and are resilient to the current and future effects of climate change.

As of September 2024, the government has signalled changes to the NPS-UD to enable housing growth including more housing in greenfield and brownfield areas, the removal of urban boundaries in planning documents and more intensification (Rearic & Harris, 2024).

Resource Management System Changes

Since the development of MDH-1, and within the duration of this project, there have been significant changes made to the resource management system, and further changes have been signalled. Key changes during that time are summarised below.

Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021

The Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021 speeds up implementation of the National Policy Statement on Urban Development 2020 (NPS-UD), enabling more MDH to be built in Aotearoa New Zealand's largest cities. It makes changes to density planning laws and supports the development of three homes up to three storeys on each site, without the need for resource consent. The Act also:

- Requires Tier 1 councils in Auckland, greater Hamilton, Tauranga, Wellington and Christchurch to change their planning rules so most of their residential areas are zoned for MDH and to publicly notify their new rules and policies enabling medium density and intensification in their district plans by 20 August 2022.
- Creates a new streamlined process so these councils can implement the NPS-UD's intensification policies faster.

Schedule 3A of the Act set out Medium Density Residential Standards (MDRS) to be incorporated by specified territorial authorities, including rules relating to density. In July 2024, the government announced that councils would have the ability to opt out of the MDRS, once they demonstrate how they will meet new Housing Growth Targets.

The Natural and Built Environment Act 2023 and Spatial Planning Act 2023

The previous government undertook a major programme of resource management reform. The proposed changes were designed to better protect the environment, support urban development and housing supply and align the system with work to adapt to the impacts of climate change and reduce greenhouse gas emissions. The intention was to replace the Resource Management Act with three new Acts:

- The Natural and Built Environment Act (NBA), as the main replacement for the Resource Management Act (RMA), to protect and restore the environment while better enabling development.
- The Spatial Planning Act (SPA), requiring the development of long-term regional spatial strategies (RSS) to help coordinate and integrate decisions made under relevant legislation.
- The Climate Adaptation Act (CAA), to address complex issues associated with managed retreat.

The Natural and Built Environment Act and Spatial Planning Act were passed into law in 2023. In December 2024 both Acts were repealed by the new coalition government.

The government has since introduced a Fast-track Approvals Bill, which may be passed into law in 2024. The purpose of the Bill is to provide a fast-track decision-making process that facilitates the delivery of infrastructure and development projects with significant regional or national benefits.

Work is also underway to make amendments to the Resource Management Act 1991 and the National-Act coalition agreement signals an intention to replace the RMA with new laws based on the enjoyment of private property rights as a guiding principle.

Appendix Two - Medium density and low carbon - tools and guidance reviewed

One Planet Living Principles

The One Planet Living (https://www.bioregional.com/one-planet-living) approach provides a framework to support action within the limits of the planet. It includes 10 principles that promote long-term goals to improve resilience and reduce climate impact.

Table 18: Summarised One Planet Living Principles

Zero carbon energy	Making buildings and manufacturing energy efficient and supplying all energy with renewables
Culture and community	Nurturing local identity and heritage, empowering communities and promoting a culture of sustainable living
Local and sustainable food	Promoting sustainable humane farming and healthy diets high in local, seasonal organic food and vegetable protein
Travel and transport	Reducing the need to travel, encouraging walking, cycling and low-carbon transport
Materials and products	Using materials from sustainable sources and promoting products which help people reduce consumption
Zero waste	Reducing consumption, reusing and recycling to achieve zero waste and zero pollution
Sustainable water	Using water efficiently, protecting local water resources and reducing flooding and drought
Land and nature	Protecting and restoring land for the benefit of people and wildlife
Equity and local economy	Creating safe, equitable places to live and work which support local prosperity and international fair trade
Health and happiness	Encouraging active, social, meaningful lives to promote good health and well-being

The approach has been applied in a range of settings internationally, including management plans for local councils, communities and businesses, as well as providing specific direction for building and multi-unit developments to tackle embodied and operational carbon. The One Planet Living framework is designed to support the creation of an action plan or route map towards a more sustainable future. It includes an extensive array of actions which highlight what is required to meet low or zero carbon goals. These are summarised below as they relate to either embodied or operational carbon.

Table 19: One Planet Living – Actions to reduce embodied and operational carbon

Actions to reduce embodied emissions	Actions to reduce operational emissions
■ A planned show-home to highlight the use of low-carbon timber construction and phase change materials for latent heating and cooling. ■ Thermal design ■ Tree canopy returned to 30% of site area ■ Recycled and reclaimed building materials – particularly bricks and timber ■ Local materials (50% within 35 miles) ■ Alternatives to PVC	■ Shared solar micro grids ■ The use of 100% renewable electricity ■ Electric vehicle infrastructure ■ Community engagement strategies ■ Residential welcome and information packs ■ Rainwater harvesting ■ Car share / car club platforms ■ Personalised public transport information ■ Onsite cycle storage ■ Private-public partnership funding for battery storage ■ Coworking spaces to enable working at home ■ Energy efficient appliances ■ Workshops on sustainable living ■ Thermally broken aluminium windows ■ Grid powered energy from renewable suppliers ■ Smart energy meters ■ Solar hot water ■ Rainwater for irrigation and toilet flushing ■ Grey water systems
Actions that reduce embodied and operational emissions	
■ 7.5-star residential rating (Building Code of Australia energy efficiency measure) ■ Less than 1 parking space per unit on average ■ Targets for 30% edible trees in public spaces	

One Planet includes guidance for conducting surveys amongst residents. While this is not as extensive as the approach in MDH-1, it does cover topics including satisfaction with living arrangements, amenities and community interaction, as well as establishing levels of activity, transport patterns, diet, and consumption choices. Also, while this does not specifically include energy use behaviours, the approach does offer an environmentally focused assessment of residents' choices.

Concepts to consider in developing MDH-C:

- Setting targets and using indicators to monitor progress (e.g. using 100% renewables, sourcing 50% of materials within 35 miles) may be overly prescriptive, and difficult to achieve and monitor, for
- The extent to which food actions and other consumption aims could be included.
- The extent to which developers should be responsible for encouraging active and low-carbon transport.

Nightingale Housing

Nightingale Housing (https://nightingalehousing.org) is an Australian not-for-profit which uses a community investment model, where future residents who share similar social and environmental values contribute to the design of the building and its amenities. The Nightingale approach incorporates the principles of 'reduction' and 'architecture of shared space' to improve sustainability and affordability and matches with residents who value community living e.g. sharing spaces and facilities such as laundries and transport in order to reduce resource use. This approach was highlighted in a 2017 article on The Commons - 24-unit housing development featured in Archipreneur magazine:

> *"It's the building's communal orientation that makes its environmental credentials possible, which reflects an understanding that achieving genuine sustainability is as much about changes in lifestyle as it is about technology or even "Architecture" as it is conventionally understood."*

Key aspects and specific outcomes of the Nightingale Housing approach that reduce GHG emissions are shown below.

Table 20: Summarised Nightingale Housing outcomes

Build less, give more	■ Smaller building footprint enabled by shared facilities lower construction and maintenance costs.
Simply sustainable	■ Sustainability of 'reductionism' leaving out what is not needed.
Carbon neutral	■ 100% carbon neutral in operation - certified sustainable energy providers, communal rooftop solar.
Sustainable transport	■ Buildings located in areas accessible by active and public transport, partnerships with car-share providers avoiding car parking spaces.
Comfortable energy efficient homes	■ At least a 7.5 star Nabers rating with high thermal insulation, passive ventilation, external shading. ■ Recycled, natural, locally-sourced and low embodied energy materials are incorporated wherever possible.
Healthy homes and gardens	■ Reduction of hazardous materials (low VOC finishes; raw metal fittings). ■ Gardens supply food and encourage physical / mental well-being. ■ Rainwater harvesting. ■ Green facades to prevent urban heat islands and raise amenity.
Reduced cost-of-living	■ Shared roof-top solar and bulk purchasing of energy. ■ Commercial internet connections service the whole building and enable lower costs for individuals. ■ Access to car-sharing and public transport reduces the need for a private cars and vehicle space. ■ Well-designed buildings maintain comfortable temperatures from predominantly passive means. ■ Airtight building fabric and increased insulation reduces heating and cooling requirements.

Concepts to consider in developing MDH-C:

- Actions to reduce building footprint – adopt reductionism and the architecture of shared space.
- Whether carbon off-setting is an acceptable approach to reduce GHGs in the medium-to-longer term.

- The extent to which buildings can be expected to be positioned close to transport hubs.
- Whether operational emissions should include those from fossil fuel-powered vehicles.
- Increase the emphasis on building performance to reduce the need for additional heating, cooling, and ventilation.
- How community gardens and other shared spaces could be commissioned or tested among residents.
- The fundamental importance of community interaction (and building design and amenity provision that supports this) to encourage significant emissions reductions.

LETI Climate Emergency Design Guide

The LETI *Climate Emergency Design Guide – How new buildings can meet UK climate change targets* (http://www.leti.london) provides comprehensive direction for low-carbon building with indicators and targets based on building type and scale. This is set within a comprehensive framework to assess both operational and embodied carbon. The objectives and associated actions to reduce embodied carbon are considered to be of most relevance to MDH-C.

Table 21: Summarised LETI Climate Emergency Design Guide objectives

Embodied carbon objectives	Summary of relevant actions
Build less	■ Consider retrofit or use of existing / recycled materials sourced on or near the site. ■ Simplify design to ensure all proposed materials are necessary.
Build light	■ Reduce weight and transport loads of materials.
Build wise	■ Use long lasting materials. ■ Build to an existing template or design repeatable modules. ■ Reduce the need for excavation or reuse excavated soil.
Build low-carbon	■ Reduce use of high emissions materials targeting the highest emitters .
Build for the future	■ Consider future uses, adaptability and end-of-life deconstruction, reuse and recycling.

Concepts to consider in developing MDH-C:

- The extent that recycled and low emission materials may be available in Aotearoa New Zealand and if these can be locally sourced.
- Encouraging a reduction in high emissions materials through design (e.g. reduced concrete / recycled bricks etc).
- Design for the building's whole life including reuse, efficient deconstruction and recycling.

Low-carbon living cooperative research centre

The Cooperative Research Centre for Low-carbon Living (resources are now hosted at www.lowcarbonlivingcrc.edu.au) was an Australian research and innovation hub focusing on policies and practices to lower carbon emissions and increase energy efficiency.

The Centre's Guide to Low-carbon Residential Buildings – New Build aims to reduce GHG emissions associated with the construction and operation of a new home. It offers a strong and proactive approach to emissions reduction. Page 1 notes:

> *"A new house is an opportunity; not only to ensure affordability and the best possible liveability for future occupants, but to create high-performance dwellings that actively 'give back' by generating more power than they use, collecting and recycling water and reducing the built environment's carbon footprint."*

Key principles support detailed guidance relating to building design and residents' behaviour.

Table 22: Summarised Principles in the Guide to Low-carbon Residential Buildings

Affordability	On-going operational costs are a critical part of low-carbon sustainable home.
Green Building	Good social, economic and environmental outcomes must be achieved alongside low GHG emissions.
Efficiency	Energy efficiency should be a priority, even when low-carbon, renewable energy is available.
Behaviours	Buildings don't use energy, people do. The way occupants use a house will have a large impact on its GHG emissions, regardless of the low-carbon principles employed in its design and construction. Assessment of operational emissions should be based on actual measured performance accounting for occupant behaviour.
The Big Picture	Climate change cannot be reduced through low-carbon housing alone, but rather by tackling emissions from all human activities.

The guide presents three benchmarks for developers to aspire to in the early planning stages as they consider targets for low emissions design and operation.

- **Operational GHG reduced and offset**: Using a carbon inventory template, 100% of annual GHG from any gas, electricity, use of mains water and transport are offset along with an additional 5%
- **Embodied and operational GHG reduced and offset**: As above 105% of embodied emissions are offset over 3 years along with 105% of operational emissions.
- **Zero Energy Home (ZEH)**: generates at least as much energy as it uses through highly efficient buildings with optimal solar power either off-grid or balancing power taken from the grid with no reliance on fossil fuels.

A simple template is provided to help calculate operational emissions by measuring total kilowatt hours (kWh) used annually from electricity, gas and other fuels as well as total consumption of water (kL). Within this framework, detailed guidance is provided across five key areas which are summarised below.

Table 23: Summarised Guidance Guide to Low-carbon Residential Buildings

Building and landscape	
Orientation and passive design	■ Understand local climate and weather factors. ■ Consider orientation of site to maximise opportunities for passive design. ■ Design the layout of the home for solar gain and to increase natural light to living areas. ■ Ensure performance of the building envelope in line with and beyond regulations. ■ Design windows and shading to manage changes in temperature. ■ Utilise cross ventilation to capture breezes by understanding prevailing wind directions and creating a simple pathway through the home with suitable exit points that are at least three times larger than entrance openings. ■ Design to account for thermal mass so heat can be stored from direct sunlight in the winter while shaded mass can release heat in the summer providing a cooling effect. ■ Additional Passive House characteristics will add further opportunities through increased air tightness and lighter construction with reduced need for thermal mass (see section on Passive House below for further discussion). ■ Choose construction materials with lower embodied energy or which have been reused or recycled.
Outdoor landscape and garden design	■ Trees to provide shade and plants that encourage evapotranspiration (loss of water from vegetation to the atmosphere) will enhance passive design performance by reducing heat islands and encouraging cooling. ■ The use of permeable paving will support evaporative cooling and help with managing stormwater. ■ Consider green roofs and walls to provide additional insulation and reduce the need for winter heating and summer cooling. Note these come with a trade-off as they may require significant water to maintain. ■ Add strategic windbreaks to reduce effects of prevailing winds or funnel air to improve cooling during summer months.
Services	
Hot water	■ Identify potential for direct solar hot water systems, hot water heat pumps or a combination of photovoltaic energy combined with a hot water heat pump. ■ Depending on the energy supply systems, load-shifting provides a method where excess energy from on-site renewable systems (e.g. photovoltaic panels) can be diverted to heat water. ■ Ensure effective use of pipe lagging, timers, and thermostatic controllers to maximise systems efficiency.
Space heating and cooling	■ Use ceiling fans as an efficient means to move air for cooling in summer and to evenly distribute warmed air in winter. ■ Identify zones in the home by the levels of heating and cooling that they require (e.g. living areas vs bedrooms). Centralised systems are often inefficient at dealing with multiple zones. ■ Additional heating and cooling (above that provided by passive design elements) should use low-carbon energy where available. Efficient systems

	include central hydronic systems (hot water distributed under floors and to radiators) which have a built-in solar mass and heat pumps.
Appliances and lighting	■ Effective design will maximise natural daylight (without unwanted heat). ■ Determine best use and placement of efficient bulbs, sensors, and timers to provide appropriate lighting based on needs in each zone of the home. ■ Add a central switching circuit to enable the ability to turn off all non-essential appliances without the need to check if each individual appliance is on. ■ Choose the most energy efficient appliances that use minimal power when on standby (phantom load). ■ The use of intelligent systems (enabling remote or smart control of appliances) can increase convenience, however they may add some complexity and associated standby loads. Early incorporation into home design may help ensure that these systems enhance low emissions objectives.
Energy	
	■ Renewable systems are only considered zero carbon if all embodied and operational emissions are offset. The use of solar, wind and hydroelectric systems will be determined by regulations, budget, site size, building orientation, prevailing conditions as well as the anticipated energy requirements of the inhabitants to meet emissions goals. ■ Load-shifting increases the attractiveness of renewable sources that can heat water, charge cars or power washing machines when not in high operational demand. ■ Energy payback for solar PV is estimated at 2-3 years – the time taken for the systems to have produced as much energy as was consumed during their manufacture and installation.
Monitoring and management	■ Monitoring systems that push information to users' devices e.g. phone alerts during times of high energy demand, are more effective at changing behaviour than tools that require users to go online to check status. ■ Monitoring options include clamp on meters, smart meters and systems that monitor individual loads (e.g. hot water). ■ Associated management options include timers or controls which are linked to temperature or light levels to operate washing machines, heating, shade controls, ventilation, or lighting systems.
Water	
	Delivery of water and treatment of wastewater generate significant GHG emissions. Strategies to reduce water use include: ■ Selection of appropriate plants, soil improvement and mulching to reduce the need for watering gardens. ■ Hydrozoning plants with similar requirements to tailor watering strategies. ■ Efficient irrigation through timers, drip irrigation, evapotranspiration and soil moisture sensors. ■ Use of rainwater and grey-water sources in both the home and garden. ■ Efficient water appliances e.g. showers, taps, toilets and washing machines. ■ Efficient plumbing will have lagged pipes and keep the bathroom, toilet, laundry, and kitchen close to the hot water tank to reduce hot water travel. ■ Realtime monitoring of water use will provide behavioural feedback.

Occupancy and operation	
	■ Monitoring, communication of energy and emissions use and education are key elements within a strategy to change household behaviours. ■ Reduce food waste by designing kitchens and pantries that encourage cooking with raw food and store food in bulk (thereby reducing packaging). ■ Transport emissions can be reduced by providing charging points for electric cars and bicycles, secure cycle storage and access to local car-sharing systems.

Concepts to consider in developing MDH-C

- Behaviours that lead to low operational emissions are encouraged by design but determined by use. This suggests the importance of ongoing information to residents about continually improving efficiency.
- The extent to which responsibility for emissions extends beyond the building to all actions taken by residents (e.g. transport and food).
- Appropriateness of stringent targets for MDH-C target audience.
- Overall, key topics and associated actions provide a useful review of things to consider including approaches to design, outdoor planting, energy supply, monitoring, water and provision of information to residents.

Living Future

The Living Future Institute (https://living-future.org.au) provides a concept of regenerative design for building projects to move beyond "merely being 'less bad' towards being truly regenerative". Its Living Building Challenge programme focuses on living buildings that give more than they take, creating a positive impact on the human and natural systems that interact with them. The Challenge is based on seven key performance areas called petals, which are summarised below.

Table 24: Living Building Challenge key performance areas

Place…restore the relationship between buildings and place	
Ecology of place	…to protect wild and ecologically significant places and encourage ecological regeneration and enhanced function of the communities and places where projects are built.
Urban Agriculture	…to integrate opportunities for connecting the community to locally grown fresh food by dedicating a proportion of their total project area to this purpose and enabling direct access to healthy local produce.
Habitat exchange	…to protect land for other species as more and more land is taken for human use by setting aside land equal to the project area, away from the site in perpetuity, for the purposes of habitat improvement.

Human scaled living	…to contribute toward the creation of walkable, pedestrian-oriented communities that reduce the use of fossil fuel vehicles through the provision of suitable storage spaces and EV charging stations, and by actively reducing single occupancy vehicle trips through transit subsidies, carpooling coordination, subsidised EVs and regular surveys to determine changes in fossil fuel usage.
Water …create developments that operate within the water balance of a given place and climate	
Responsible water use	…to treat water like a precious resource, minimising waste and the use of potable water, while avoiding downstream impacts and pollution by using grey and rainwater systems where possible.
Net positive water	…water use and release to work in harmony with the natural water flows of the site and its surroundings with all projects supplying 100% of water needs through captured precipitation or other natural closed-loop systems where possible with purification achieved without the use of chemicals. A resilience strategy requires suitable onsite storage of drinking water for one-week for all residents.
Energy…eliminate the wasteful spending of energy, resources and dollars	
Energy and carbon reduction	…to treat energy as a precious resource and minimise energy- related carbon emissions that contribute to climate change by setting energy reduction targets for new buildings (70% from equivalent baselines) and existing buildings (50% from equivalent baselines). Energy use is to be monitored with a 20% reduction in embodied carbon of primary materials compared to an equivalent baseline.
Net positive energy	…to foster the development and use of carbon-free renewable energy resources while avoiding the negative impacts of fossil fuel use, primarily the emissions that contribute to global climate change. Projects must supply 105% of their energy needs through on-site renewables while accounting for the total embodied carbon emissions through sequestering or offset purchases and provide for one-week of the building's operational energy through storage.
Health and happiness…create healthy spaces that allow all species to thrive by connecting people to nature and ensuring that our indoor spaces have healthy air and natural daylight	
Healthy interior environment	…to promote good indoor air quality and a healthy interior environment for project occupants through compliance with standards for ventilation, prohibiting smoking indoors and developing cleaning protocols and providing views from at least 75% of regularly occupied spaces.
Health interior performance	…to demonstrate ongoing high-quality indoor air and a healthy indoor environment by conducting post occupancy tests, using cleaning products that exhibit Safer Choice labelling, providing windows that enable ventilation and the ability for occupants to influence their own airflow and temperatures.
Access to nature	…to provide opportunities for project occupants to directly connect to nature through both interior and exterior spaces assessed through post occupancy evaluation that includes access to daylight, fresh air and access to natural surroundings.

Materials…*help create a materials economy that is non-toxic, ecologically restorative, and transparent*	
Responsible materials	…to set a baseline for transparency, sustainable extraction, support of local industry and waste diversion including requirements for 50% of wood products to be FSC labelled or salvaged, at least 20% materials budget comes from within 500kms of the site, 80% of construction waste diverted from landfills and the provision of recycling and composting facilities to all occupants.
Red list	…to foster a transparent materials economy free of toxins and harmful chemicals by avoiding Red List chemical classes (as listed in page 53 of the guidance) in 90% of the project's new materials by cost.
Responsible sourcing	…to support sustainable extraction of materials and transparent labelling of products by adhering to certified standards for sustainable extraction and fair labour practices.
Living economy sourcing	…to support local communities and businesses, while minimising transportation impacts by setting limits on expenditure for materials sourced within 500, 1000 and 5000 kms.
Net positive waste	…to integrate waste reduction into all phases of projects and to encourage imaginative reuse of salvaged "waste" materials.
Equity… *a just and inclusive community that enables all people to participate, prosper, and reach their full potential. is in the best position to make decisions that protect and restore the natural environment that sustains all of us.*	
Universal Access	…to allow equitable access to, and protections from negative impacts resulting from the development e.g. not blocking access to, nor diminishing the quality of, fresh air, sunlight, and natural waterways for any member of society or adjacent developments.
Inclusion	…..to help create stable, safe, and high-paying job opportunities for people in the local community, and support local diverse businesses.
Beauty … *recognising the need for beauty and the connection to nature as a precursor to caring enough to preserve, conserve, and serve the greater good.*	
	…embracing our connection to nature and what we, as a society, choose to value.

Concepts to consider in developing MDH-C:

- Introduce the concept of regenerative design.
- A holistic approach and net positive outcomes –includes rigorous targets for water use and energy reduction.
- Language may not be suitable for the intended audience.
- It is only possible to support the local economy through sourcing local building materials if they are available.

Passive House

Passive House (http://www.passivehouse.nz) is a European housing performance standard for extremely low emissions housing based on design and construction techniques that result in:

- Airtightness – reducing leakage throughout the building.
- High levels of insulation – exceed requirements.
- Windows and doors with high thermal performance – well sealed, thermally-broken frames with double or triple glazing.
- Minimising thermal bridges – to reduce heat conduction between the outside and inside of the building.
- Mechanical ventilation systems with heat recovery and vapour control – required when windows are closed.

A home built to Passive House standards can be of a lighter weight construction as the internal airmass means that thermal mass can be reduced. The Passive House High Performance Construction Details Handbook 04.22 details typical high-performing construction elements and junctions and gives embodied kg-CO_2 for some of these. It is worth noting that, while these junctions and elements may become more common in the near future, they are not indicative of current construction techniques in New Zealand.

That said, Passive House is gaining traction from a low base in the NZ housing market. Kāinga Ora are currently trialling it, with their Bader Ventura development. This is the first Passive House pilot development for Kāinga Ora and the first in its Carbon Neutral Housing Programme.

Concepts to consider in developing MDH-C:

- A Passive house requires significant behavioural changes from residents in order to operate effectively. - how easily will these be accepted by New Zealand residents?

Aotearoa New Zealand guidance

BRANZ MDH and Climate Change

BRANZ has invested heavily in research to support the building industry to design, consent and build high-quality, affordable medium density housing. MDH-1 tool was funded by BRANZ as part of its MDH work programme.

Over the past two decades BRANZ has also carried out, and funded, extensive research into climate change and the built environment. Key outputs from this work include a range of carbon calculators, including life cycle assessment tools, which can be applied to a range of building typologies to calculate and iteratively reduce or design out carbon. BRANZ medium-density housing website (https://www.branz.co.nz/mdh/) provides a range of resources including a series of factsheets on MDH.

New Zealand Green Building Council

Homestar is a rating tool that provides a robust framework for assessing a range of environmental, sustainability and health features amongst a range of New Zealand dwellings. In recent years, the tool has been extended to assess and rate multi-unit developments in six core areas. http://www.nzgbc.org.nz

Table 25: Summarised core areas of the Homestar rating tool

Category	Description
Energy, Health and Comfort	Attributes that contribute to reduced energy use within the dwelling, for example energy efficient lighting, energy rated appliances and attributes that contribute to occupant thermal comfort, e.g. insulation and bathroom ventilation.
Water	Contribution to reduced water consumption, e.g. low water flow taps and toilets.
Waste	The ability to readily recycle waste, as well as construction practices that reduce waste going to landfill.
Home Management	Dwelling attributes that contribute to making a safe, secure and adaptable dwelling.
Materials	The use of responsibly-sourced products and materials that have lower environmental impacts over their lifetime including interior finishes that minimise indoor pollutants including Volatile Organic Compounds (VOCs).
Site	Effective stormwater management, the contribution to local ecology, the ability to grow food on site and the location of the dwelling in relation to key amenities.

Homestar has been expanded to include the Homestar Embodied Carbon Calculator, developed with BRANZ to rapidly inform climate change impacts in CO_2 of chosen residential design solutions.

NZGBC tools also include Green Star Communities which assesses the planning, design and construction of large-scale development projects including precincts, neighbourhoods, and entire communities against a framework including governance, liveability, economic prosperity, environment (including a GHG strategy) and innovation.

Concepts to consider in developing MDH-C:

- The Homestar approach encompasses a robust set of categories and sub-categories for assessment and is already achieving some uptake in the market for medium density housing.
- Sustainability of the built environment is a vital aspect of any new development. MDH-C aims to cover this as well as broader community-related and social aspects that can also reduce impacts on climate.
- MDH-C should not seek to replicate Homestar or the Embodied Carbon Calculator but encourage their use amongst appropriate developments.
- Categories, or sub-categories that show potential alignment with MDH-C include: materials, energy, health and comfort, water efficiency and harvesting, stormwater management, waste and aspects of management such as a user guide for the home.

Ngā tohutohu hoahoa ā-motu mō te wharenoho mātoru-waenga - National Medium Density Design Guide

This guide was developed by the Ministry for the Environment to help achieve well-functioning and high-quality MDH that is integrated into its neighbourhood. It is aimed at small-scale property owners or those with limited experience in more complex residential developments. The focus of the guide is on three-unit developments up to three storeys in height that are now permitted under the medium density residential standards, although the design elements covered in the guide may also apply to a range of residential developments. The guide uses non-technical language while highlighting the importance of developments that consider landscape, community and neighbourhood integration.

This guide, covers similar elements to MDH-1 albeit through a different approach:

- The site: A part of the community.
- In the front: A welcoming address.
- On the side: A good neighbour.
- The house: A well-configured building.
- Around the house: An integrated landscape.
- In the house: A liveable home.

Concepts to consider in developing MDH-C:

- The approach aligns well with the MDH-C target audience.
- Confirms the use of less technical language to engage less experienced developers.

Te Aranga Māori Design Principles

Te Aranga Māori Design Principles were developed by Māori design professionals as a response to the New Zealand Urban Design Protocol in 2005. The Principles exist in a number of formats and the project team utilised the synopsis adopted by Auckland Council (with support of Ngā Aho, a Māori design professionals network) and provided as part of the Auckland Design Manual http://www.aucklanddesignmanual.co.nz/design-thinking/maori-design/te_aranga_principles.

They are a set of outcome-based principles founded on Māori cultural values and formulated to provide practical guidance to enhance outcomes for the design environment, and address the processes of economic, social, environmental and spatial development changes.

The core values listed below are the way of engaging and collaborating within Te Ao Māori (the Māori world) and within Te Ao Hurihuri (the changing world).

For Māori, these values not only represent their own personal and collective beliefs and values, but they provide a means of asserting identity of self and place, enhancing the overall presence, visibility, and participation of mana whenua in the design of the physical realm. This enables the development community to understand how all can positively engage with mana whenua to shape our natural and built environment.

Table 26: Seven Te Aranga Māori Design Principles

Principle	Description
Rangatiratanga	The right to exercise authority and self-determination within one's own iwi / hapū realm.
Kaitiakitanga	Managing and conserving the environment as part of a reciprocal relationship, based on the Māori world view that we as humans are part of the natural world.
Manaakitanga	The ethic of holistic hospitality whereby mana whenua have inherited obligations to be the best hosts they can be.
Wairuatanga	The immutable spiritual connection between people and their environments.
Kotahitanga	Unity, cohesion and collaboration.
Whanaungatanga	A relationship through shared experiences and working together which provides people with a sense of belonging.
Mātauranga	Māori / mana whenua knowledge and understanding.

The following core values guide the practical application of seven Te Aranga Māori Design Principles:

Table 27: Core Values that guide the application of Te Aranga Māori Design Principles

Core Value	Description
Mana Rangatiratanga (Authority)	The status of iwi and hapū as mana whenua is recognised and respected.
Whakapapa (Names and naming)	Māori names are celebrated.
Taio (The natural environment)	The natural environment is protected, restored and / or enhanced.
Mauri Tu (Environmental Health)	Environmental health is protected, maintained and / or enhanced
Mahi Toi (Creative expression)	Iwi/hapū narratives are captured and expressed creatively and appropriately.
Tohu (The wider cultural landscape)	Mana whenua significant sites and cultural landmarks are acknowledged.
Ahi Kā (The living presence)	Iwi/hapū have a living and enduring presence and are secure and valued within their rohe.

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Concepts to consider in developing MDH-C:

- The design process identifies landscape and building materials that are locally sourced and of high value to mana whenua which should be encouraged where possible.
- Connectivity to significant sites and landmarks are promoted and enhanced visually, identified through heritage trails, signage and relevant information.
- The restoration and protection of natural environments enable sustainable harvesting by mana whenua where possible.
- Local fauna and flora that are significant to mana whenua remain key elements in urban and modified landscapes.
- Efforts should be encouraged to maintain and enhance biodiversity including the creation or maintenance of ecological corridors and waterways, planting of native species and the use of seasonal species markers to attract native animal and bird life.
- Air, water, land and sea quality is actively monitored.
- Resources are preserved and conserved by recycling or using sustainable sourcing where possible.

Kāinga Ora Design Guides

Kāinga Ora (https://www.Kāingaora.govt.nz) is the largest developer in New Zealand and as such has developed Large-Scale Urban Development Guides for their organisation and delivery partners. These provide a useful overview for consideration in MDH-C as they cover topics and targeted outcomes for community including intergenerational living, the environment and environmental protection as well as the residents' experience.

Table 28: Kāinga Ora Design Principles

Principle	Description
Tāone ora Thriving and sustainable communities	Urban design helps build lives and communities by delivering cost-effective design solutions to create built form that fosters community well-being, enhances streets and public spaces, and shows respect for local character and amenity values. Tāone Ora is the principle of ensuring that the relationship between urban and natural environments provides both for one another, and for people, sustaining the well-being of our communities and providing for safer and healthier lifestyles and places.
Tangata ora Multi-generational and inter- generational inclusivity	Whānau (family) and hapori (community) are key. As Aotearoa transitions towards more collective living, it is important that we seek out opportunities for multi-generational and inter-generational living. The way we design and build can inform and provide environmental, social and cultural benefits through creating interconnected, inclusive and accessible places delivering mixed housing typologies, facilities and infrastructure to support and sustain families and communities. Tangata ora reflects the importance of catering to the needs and well-being of people – elderly, adults, youth and children. The communities we develop should respond to and include all members within the whānau unit, to help improve the health, well-being and identity of our environments and for the people.

Whenua ora Protecting environments	Urban design should also benefit, protect, retain and/or restore our natural landscapes, ensuring that we contribute to and improve the quality of healthy lives for all living things. It is important that urban design responds across scales, taking into account the wider landscape understanding natural and built systems, significant landscape features (maunga, ngahere, awa, moana) with relation to the site- specific context. Whenua ora is the principle of recognising and understanding the layers of the landscape (whakapapa) and how urban design can inform the interface between the built and natural environments, benefiting functioning systems (ecological and infrastructure), and provide for safer and healthier neighbourhoods and communities.
Tūhononga The residents' experience	The quality of the residents' experience is an essential measure of successful residential developments. The perception of a place and its people can be heavily influenced by the quality and character of its setting and the level of external amenity that setting can offer. Providing attractive and functional buildings can enable our residents to take pride in their home and environment. Tūhononga is the principle of connections, enabling residents to feel connected to their surroundings.
Mahi tahi Partnership and participation	Successful urban design is attributed to collaboration, drawing together different professions and sectors, mana whenua and communities, within the overall decision-making process. The process of partnership and participation is important, allowing opportunities for heritage, identity, stories and collective values to inform design outcomes. The principle of mahi tahi reflects the importance of working together. It recognises the integrity of building and maintaining meaningful relationships while also reflecting our obligations as Treaty partners.
Āhurutanga Safe living environments	The design of the built environment can have a significant impact on personal safety, security, crime, and social behaviour within a neighbourhood. Urban design plays a critical role in enabling safer and more attractive neighbourhood environments by applying Crime Prevention Through Environmental Design (CPTED) principles. Āhurutanga is the principle of feeling comfortable within the spaces we inhabit – a place to call home.

These principles are supported by comprehensive information and checklists to consider a wide range of issues relating to neighbourhoods, the site, and buildings.

Concepts to consider in developing MDH-C:

- A comprehensive resource with extensive information and overlap with the intentions of MDH-C.
- Confirms the importance of the community and the residents experience.
- As a key stakeholder, and the largest developer in New Zealand, it is important that MDH-C aligns well with Kāinga Ora principles.

Medium – a technical design guide for creating better medium density housing in Aotearoa New Zealand

Medium draws together research across Aotearoa and provides guidance on a number of areas key to the development of the MDH-C core outcomes.

The document usefully draws together research, providing a list of issues raised by architects and designers, residents, academics and housing experts. In relation to creating community, the guide identifies the spatial types below that may promote positive community-building and notes that they need community governance that supports inclusivity and collaboration.

- Spaces of primary circulation - the way in which residents move about a development provides opportunities for social connectedness and should be considered in designing locations of facilities. This includes allowing for points of pause for everyday social encounters.
- Spaces of shared utility—spaces for tasks not suited for inside the house such as a shared workshop or a designated space for shared vegetable gardening.
- Spaces of primary recreation – if there are no nearby recreational opportunities, the design should encompass spaces to play, kick a ball or do yoga in the sunshine either at ground level or on the rooftops.
- Spaces of primary sociality- at least one location should be designated for shared social activities e.g. a shared kitchen, or BBQ
- Spaces of primary repose – the development should include a dedicated space of rest, peacefulness, or a spot to connect with nature's dynamics.

Concepts to consider in developing MDH-C:

- Types of spaces and needs for these within a development

Local government housing and medium density housing guides

https://www.mdh.org.nz/regional-rules/

Many councils have specific design and planning rules related to Medium Density Housing and a number of these were reviewed. While most of these did not refer explicitly to carbon, or did so in a conceptual rather than practical manner, they did offer some direction in terms of framing MDH-C and the use of non-technical language.

The tools reviewed ranged from simple high-level guidance to more detailed advice and included:

- Northland -Whangārei District.
- Auckland - Auckland planning rules are intended to create a high-quality and more compact built environment that complements the unique and natural qualities of the city.
- Waikato - Hamilton City, Hauraki District and Taupō District.
- Bay of Plenty - Rotorua District, Tauranga City and Western Bay of Plenty District.
- Hawke's Bay - Hastings District and Hawke's Bay Region.
- Manawatu-Whanganui - Horowhenua District, Palmerston North City and Whanganui District.
- Taranaki - New Plymouth District.
- Wellington - Kāpiti Coast District, Lower Hutt City, Porirua City, Upper Hutt City, Wellington City and Wellington Region.
- Nelson - Nelson City.
- Marlborough -Marlborough District.

- Canterbury - Ashburton District, Christchurch City, Selwyn District, Timaru District and Waitaki District.
- West Coast - rather than each of the three West Coast District Councils preparing individual plans, Te Tai o Poutini Plan Committee is responsible for preparing and approving a combined district plan covering the whole of the West Coast.
- Otago - Dunedin City, Queenstown Lakes District and Waitaki District.
- Southland -Invercargill City.

Some of these guides were looked at in more detail for guidance in framing and content. These are summarised below.

Auckland Design Manual

The Auckland Design Manual (https://www.aucklanddesignmanual.co.nz) provides a range of guidance, checklists and case studies to assist with design and development. These include the Sustainable Home Guide and Te Pokapū Whakatairanga Tikanga Māori - Māori Design Hub.

The Auckland Design Manual includes a Sustainable Home Guide that looks at energy, water, comfort and health and lifecycle costs and provides a useful framework to consider sustainable aspects of a home in terms of type, scope and time of impact. (https://www.aucklanddesignmanual.co.nz/design-subjects/sustainability/shg)

Table 29: Sustainable Home Guide aspects

Type of impact	■ Place and context ■ Energy use ■ Water use and wastewater production ■ Health and comfort ■ Lifecycle ■ Waste – construction and operational
Scope of impact	■ Immediate - the effect on our own lives ■ Local - the effect on our communities e.g. minimising shading to surroundings ■ National - effect on our national environment and infrastructure e.g. reducing demand can limit the need for new infrastructure ■ International - effect on faraway communities and the planet e.g. climate change, deforestation.
Time of impact	■ Both now and into the future

Te Pokapū Whakatairanga Tikanga Māori (The Māori Design Hub) is also part of the Auckland Design Manual. This provides Māori design considerations, resources and exemplars to stimulate thinking on higher density Māori housing to provide affordable homes and make better use of land. The hub also includes information on Māori housing research, providers, policies and toolkits. https://www.aucklanddesignmanual.co.nz/design-subjects/maori-design

Hastings Residential Intensification Guide 2020

https://www.hastingsdc.govt.nz/assets/Document-Library/Hastings-Residential-Intensification-Design-Guide/Hastings-Residential-Intensification-Design-Guide.pdf

The guide provides six simple design principles – looks good, fits well, works well, feels good, connects well, and sustainability - and incorporates 11 design elements which were useful for comparing against MDH-1:

- House Types, Sizes and Adaptability.
- Entrances, Detailing and Colour.
- Building Height, Dominance and Sunlight.
- Connections to Open Space.
- Landscape Design.
- Private and Safe Environments.
- Outdoor Living Space.
- Parking and Manoeuvring.
- Waste and Service Areas.
- Site Coverage and Low Impact Design.
- Building Materials and Environmental Sustainability.

Tauranga Draft Residential Outcomes Framework 2020

https://www.tauranga.govt.nz/Portals/0/data/future/growth/housing-choice/files/residential-outcomes-framework-draft.pdf

An outcome driven framework similar to MDH1 with the following core elements:

- Site and context.
- Public domain interface.
- Movement networks.
- Private residential Amenity.
- Residential interface.
- Safety and security.
- Choice resilience and flexibility.
- Sustainability.

The checklist presented in *Section 4. Desired Outcomes Applicability Checklist* identifies specific elements to consider. Consideration of these outcomes provided useful direction for language, the framing of concepts and definitions and for a review of specific actions to include in MDH-C

Concepts to consider in developing MDH-C:

- Direction for language, definitions and the framing of concepts.
- How MDH-C sits alongside current and future local government MDH guidelines.

Appendix Three - CO_2 review methodology

Background

A CO_2 review was included as part of the prototype version of MDH-C that was tested through this project. The review was designed to assess annual operational CO_2 emissions generated by a building and its residents.

In developing the review, we drew from an existing methodology developed by the authors of *Medium Density Housing Assessment Tools: Final Report* (Ryan, V. and Smith, B. (2018) and implemented on behalf of Auckland Council as part of their Multi Unit Dwelling programme (MUD). MUDs share many characteristics with medium density housing in that they both have public and private spaces and often have residential property managers or developers with an on-going involvement with the buildings. The MUD assessment approach provides a simple approach to calculating annual energy usage and associated carbon dioxide emissions, and could easily be amended to include private residential spaces.

The MUD assessment methodology took its direction from a number of tools, guidance and reports. The most relevant of these are summarised below. For MDH-C the review methodology was refined to capture data on energy use and calculated CO_2 emissions from lighting, heating, cooling, ventilation and other appliances.

Table 30: Tools and guidance reviewed in developing MDH-C CO_2 emissions review tool

Tool	Commentary
Smart Blocks – Audit tool http://smartblocks.com.au/what-can-i-do/getting-started-what-can-you-do-your-building/audit-common-property-your-building (Link no longer working) See summary: https://www.governmentnews.com.au/smart-blocks-makes-high-rise-low-impact/	Smart Blocks was developed in Australia with contributions from the Cities of Sydney and Melbourne and the Department of Industry. The overall approach provided apartment dwellers with the means to determine energy efficiency measures. It was presented as a simple self-assessment tool available online which determined the extent of lighting heating cooling ventilation and other appliances and calculated their likely energy use.
NABERS – Lighting Calculator https://www.nabers.gov.au	NABERS (National Australian Built Environment Rating System) offers approaches to sustainability measurement across a range of building sectors. A spreadsheet to assess lighting costs provides a simple format for entering data and calculating usage in terms of kWh and costs that could easily be amended to include CO_2 emissions.
Wattblock www.wattblock.com.au	Online tool gives owners, corporations and body corporates an energy saving roadmap.

Tool	Commentary
The Carbon Trust Energy Management Self-Assessment tool - UK https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/energy-management-self-assessment-tool	A matrix and accompanying comprehensive guide for increasing energy efficiency in all building sectors. Offers information on technical aspects including energy supply and metering, lighting, heating and hot water, ventilation and air conditioning and building controls.
Energy Saving Tips for Apartments and Condos – Puget Sound Energy https://www.pse.com/en/business-incentives/multifamily-programs	A user-friendly guide to opportunities to increase energy efficiency covering heating, water heating, insulation, air leaks, lighting and appliances.
NEEP Guide for renting and creating lower cost energy efficient apartments and homes https://neep.org/sites/default/files/media-files/a_guide_for_renting_and_creating_lower_cost_energy_efficient_apartments_and_homes_-_2021_formatted_update.pdf	Tips on energy saving measures relating to insulation, draughts and glazing, meter monitoring, appliances water heating and thermostat control.
Green Impact Audit Checklist – University of London https://www.scribd.com/document/298818490/Green-Impact-Audit-Checklist-UoL	A user-friendly guide to identifying potential improvements in energy efficiency in terms of upgrading lights and lighting controls, reviewing heating, cooling and ventilation and any associated losses and or moisture build-up and determining if appliances being used inefficiently.
Making a Corporate Commitment (MACC) Site Specific Advice – Assessment Support Pack Issue August 1998 https://ia601202.us.archive.org/10/items/GPCS335/MakingACorporateCommittmentSiteSpecificAdviceAssessmentSupportPack.pdf	Comprehensive energy management matrix approach in each of the core areas for assessment (e.g. lighting, management, hot water.) Although outdated it provides a good overview for reference.
Energy Saving Tips for High-Rise Apartment Buildings in Texas July 6, 2017 by Chris Drake https://bigreddog.com/energy-saving-tips-for-high-rise-apartment-buildings-in-texas-2/ (Link no longer working)	Identifies additional areas to consider: ■ The tops and bottoms of the building. ■ Elevators. ■ Vestibules. ■ Rooftop access points. ■ Stairwells.

A CO_2 review methodology for MDH-C

These assessment tools and guidance offer relatively consistent approaches to determining energy use and associated carbon emissions in MDH or other buildings. Broadly, that includes:

- Determining the energy sources used in a building or site. These might include any solar power, renewable supply, mains electricity, or gas.
- Identifying energy-using appliances and their operating wattages.
- Determining or estimating the time (hours) they are in use for in a typical day or week.
- Considering if the appliances themselves can be either updated to more efficient models or used more efficiently (e.g. through timers, controls or detectors for lighting).
- Identifying other factors that could reduce the need for these appliances to operate (insulation, draughts, conflicts between ventilation and heating systems).
- Determining, through monitoring of energy meters, if there is excess usage outside normal seasonal variations.

These considerations form the basis for the revised CO_2 review methodology that has been adopted for MDH-C. This includes a method to calculate operational emissions from the energy used in both residences and public spaces by identifying appliances and their operating characteristics during a walk-through of the site.

In broad terms, the assessment is designed to collect data on energy usage throughout the building including in any:

- Administration offices.
- Foyer and hallways.
- Utility rooms.
- Stairways and lifts.
- Parking facilities.
- Common rooms or kitchens.
- Gym or pools.
- Common toilet or washroom areas.
- Gardens, play areas and outside pathways.
- Private residences.

The assessment identifies the number and types of appliances, their wattage and expected usage in each of these areas. These could include:

- Lighting.
- Security cameras and alarm systems.
- Heaters and hot water systems.
- Ventilation and extraction.
- Cookers.
- Washing machines and dryers, dishwashers and fridges.
- TVs.
- Other appliances as identified.

For public areas, total numbers of fixtures and appliances (e.g. lights) can be determined more easily if there is the same configuration on different floors. For residences, some example units can be assessed and then factored by the total number of units to provide an approximate energy use. Daily usage can then either be estimated, or measured, if there are any timers or controls in place, while further factoring is required to provide an annual estimate. Once total kWh are established, these can be factored by coefficients for costs (depending on the fuel type) and CO_2 emissions.

An example application is shown in the table below with some assumed entries for appliances in public spaces, followed by private residences. In this case, the cost per kWh is assumed at $0.26 and emissions are determined at 0.0742 Kg CO_2 / kWh for electricity, as determined by the Ministry for Environment (Guidance for Measuring Emissions Detailed Guide 2023).

Table 31: MDH-C CO_2 review tool example

Description / location	Appliance	Type	#/room	# of rooms / floors	Total	Watt age	Est. annual hrs	KW/h	Cost $	CO2 kg
Utility rooms										
Bike parking and waste	Lighting	LED	6	1	6	8.5	365	18.615	$4.84	1.38
Connecting stairs & hallways										
Near lift	Lighting - outside	LED	4	3	12	18	365	78.84	$20.50	5.85
Stairway	Lighting - outside	LED	1	1	1	6	1460	8.76	$2.28	0.65
Stairway	Lighting - outside	LED	3	1	3	7.7	1460	33.726	$8.77	2.50
Public toilet										
Toilet / washroom	Lighting	LED	1	1	1	12	365	4.38	$1.14	0.32
Outdoor communal space										
Outdoor rooftop	Lighting - outside	LED	4	1	4	7.7	1460	44.968	$11.69	3.34
Indoor communal space										
Indoor communal / laundry	Lighting - inside	LED	6	1	6	12	1460	105.12	$27.33	7.80
	Appliances - other	Washing machine	3	1	3			919	$238.94	68.19
	Appliances - other	Dryer	3	1	3			462	$120.12	34.28
	Appliances - other	Dishwasher	1	1	1			69	$17.94	5.12
	Appliances - other	Fridge	1	1	1			605	$157.30	44.89

Private	Lighting	Type	#/room	# of	Total	Watt-	Est.	KW/h	Cost $	CO_2 kg
Bedroom	Lighting	LED	2	13	26	8.5	365	80.665	$20.97	5.99
Living and kitchen	Lighting	LED downlight	1	13	13	12	1460	227.76	$59.22	16.90
Hall	Lighting	LED	5	13	65	8.5	365	201.6625	$52.43	14.96
Private Heating / cooling										
Bathroom	Heating / cooling	Towel rail	1	13	13	300	365	1423.5	$370.11	105.62
Living	Heating / cooling	electric fixed	1	13	13	1500	91.5	1784.25	$463.91	132.39
Private Appliances										
Living	Appliances - other	TV	1	13	13	100	730	949	$246.74	70.42
Kitchen	Appliances - other	Cooker	1	13	13	8000	100	10400	$2,704.00	771.68
Kitchen	Appliances - other	extractor	1	13	13	80	100	104	$27.04	7.72