Ministry for the Environment
Manatū Mō Te Taiao

Integrated Whole Building Design Guidelines

New Zealand Government

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Executive summary

This report has been prepared for the Ministry for the Environment to assist the Govt^3 programme's members. It provides guidance on a building's design process. The design process described in this report is the integrated whole building design process (IWBDP). By using this design process, the government aims to ensure that future government buildings are designed to be healthier and more environmentally sustainable.

This guide provides a breakdown of the processes and documentation required at each stage of the design process. Guidance is provided up to the completion of the construction phase and beyond this the Ministry for the Environment's commissioning guidance document should be used. Using these two guides in conjunction with each other will help Govt^3 agencies achieve and maintain buildings with good environmental performance over their lease term or life.

A conventional design process tends to encourage the segregation of the disciplines which can result in a fragmented design that may not meet all of the design objectives. As a consequence, environmentally sustainable design (ESD) opportunities are usually only recognised once the initial concept design is complete, which can make them difficult and expensive to incorporate. This report aims to identify a better approach to the design process to produce high-performing buildings that are more resource efficient, require less maintenance and provide healthier working environments for users and tenants.

An IWBDP is a design method which considers the building as a whole and requires the involvement of all stakeholders, design team members and future users or tenants. Design opportunities are recognised during the first stages of the design process and can be more easily and cost-effectively incorporated into the design. This design process realises the interconnectedness of disciplines and can help integrate the building services into the building structure. Input on the design from the team members, stakeholders and future users or tenants is encouraged during the very first stages of the process.

The benefits of using an IWBDP for a building can include:

- reduced operation and maintenance costs
- reduced energy consumption
- reduced water use and waste water production
- reduced waste production
- improved comfort levels for occupants
- improved productivity of occupants
- a healthier environment for occupants
- greater marketability.

To ensure that buildings designed using an IWBDP maintain their high performance, it is recommended that initial commissioning, fine-tuning and continuous energy, water and waste auditing strategies are adopted. Initial commissioning and fine-tuning will help ensure the systems within the building are performing as they were designed. Continuous auditing can be used to monitor the performance of the building and occupants in meeting agreed targets and also to give an indication of any improvements that can be made.

IWBDP project checklist

This checklist provides an overview of the principal activities involved in the integrated whole building design process.

Activity	Complete		
	Small building (≤500m^2)	Medium building (>500m^2 ≤1000m^2)	Large building (>1000m^2)
1. Require adoption of IWBDP and recommend adoption of NZCIC Design Documentation Guidelines by the project team (refer to Further reading section).			
2. Appoint an IWBDP facilitator or champion.	N/A		
3. Carry out a visioning workshop and stakeholder consultation.			
4. Summarise the project goals identified in the workshops and consultations into the outline building brief and issue to the design team as the basis for design.	N/A		
5. Carry out concept and preliminary high-level design workshops and write reports.	N/A		
6. Carry out targeted elemental developed design workshops and write a report.	N/A		
7. Specify that the design team uses Building Information Modelling (BIM) for detailed design documentation.	N/A		
8. Arrange for the independent commissioning agent and facilities manager to review the design for buildability, maintainability, and commissioning.	N/A		
9. Provide building user guide training and facilities management training.	N/A		
10. Arrange for an independent commissioning agent to oversee and report on building commissioning.	N/A		
11. Ensure building maintenance contracts are set up during the first six months of operation.			
12. Ensure first-year building fine-tuning is carried out and provide feedback to the design team.	N/A		
13. Carry out operational energy, water and waste auditing and provide feedback to the design team.			
14. Carry out post-occupancy evaluation of the building after nine months of operation and provide feedback to the design team.			
15. Carry out triennial building audits.			
16. Allow for any continuous commissioning as a result of triennial audits.	N/A		
17. Include a green performance schedule if building is leased.	N/A		

Introduction

Buildings are responsible for nearly a quarter of New Zealand's energy consumption and more than half the electricity used in New Zealand is used in buildings in some way (Cosgrove, 2006). Energy, water and materials are expected to become more expensive as resources dwindle, population and demand grow, and fuel prices increase. There is a growing movement to reduce greenhouse gas emissions and improve the resource efficiency of buildings through better design, construction methods, use of more environmentally preferred materials, and higher-performing building services systems. Sustainability is usually one of the design objectives identified by a client for a building design project.

The design of sustainable buildings requires a more collaborative approach than conventional methods allow. This is called an integrated whole building design process (IWBDP). Using this approach recognises that a building is by definition a ʽwhole' physical object, and behaves as a ʽwhole' dynamic system, both directly and indirectly with the natural world (Aitken, 1998). The IWBDP is an effective way of designing green buildings.

What is a conventional design process?

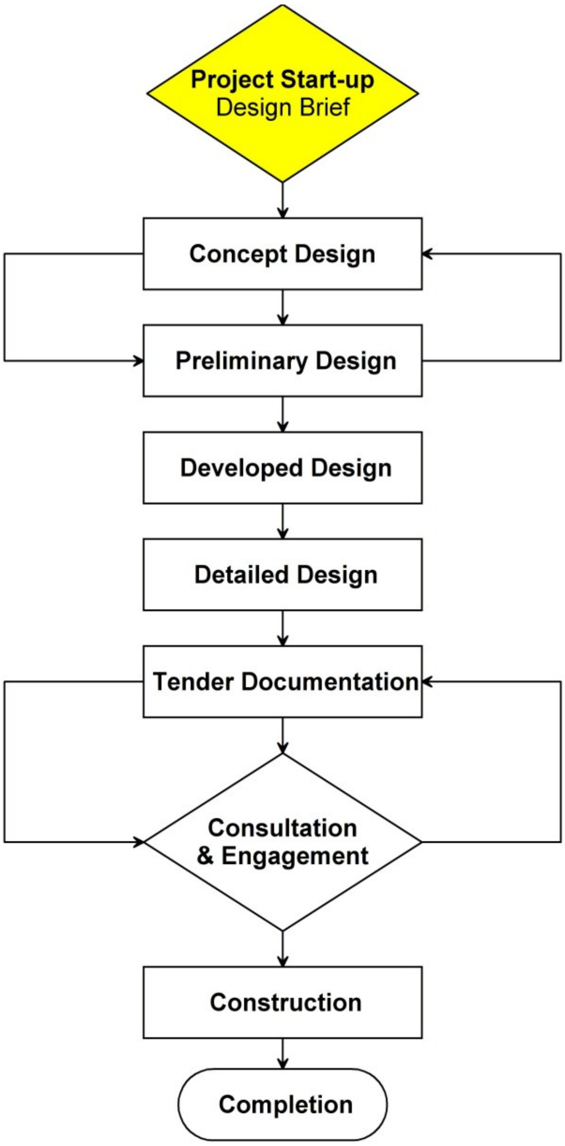
The conventional design process is a linear approach in which project goals are identified and assigned to specific members of the design team (Figure 1). The design is developed in a segregated way with minimal interaction between the design team members. The result can be solutions that do not incorporate all of the design objectives. In a conventional design process, the design team's input peaks during detailed design and reduces during the construction phase and beyond. Optimisation is difficult using a conventional design approach, and problems may subsequently occur during the operational phase of the building.

The nature of the conventional design process and the cash flow of fees is also currently front-end loaded which discourages the design team's involvement in the later construction, commissioning, post-occupancy and feedback stages of construction.

The New Zealand Green Building Council (NZGBC) Green Star rating scheme, and the rating tools the NZGBC is developing, were originally envisaged as a consistent means of measuring a building's sustainability. In many respects the Green Star rating tools promote and encourage an IWBDP. The rating tools are designed in such a way that they require the broad input of the whole team to achieve a final rating. And, in many cases, individual credits will also require the active collaboration of two or more team members. In addition, rating tools provide a clear environmental goal for the project which can be useful to maintain a centralised focus on sustainability for the whole team. However, rating tools are currently seen and used by many in the industry as design tools. In so doing, the sustainable design process can be reduced to a box-ticking exercise which to an extent disenfranchises the creativity of the design team members and, in particular, the architect.

The NZGBC Green Star system has, however, sought to encourage better involvement in the commissioning and post-occupancy stages of a building project.

Figure 1: The conventional design process



What is an integrated whole building design process?

The IWBDP is a design method which considers the building as a whole and requires the involvement of all stakeholders, design team members and future users or tenants. Integrated whole building design is a holistic, design-led approach that seeks to recognise the interconnectedness of a project's goals. Figure 2 is a schematic of the IWBDP, which is very different in structure from that of the conventional design process in Figure 1 above. This diagram shows the interactive nature of the IWBDP through the multiple feedback loops at several stages in the design.

Figure 2: The IWBDP from project start-up through to commissioning, auditing and post-occupancy evaluation (POE) and the possible feedback loops (shown by the green arrows)

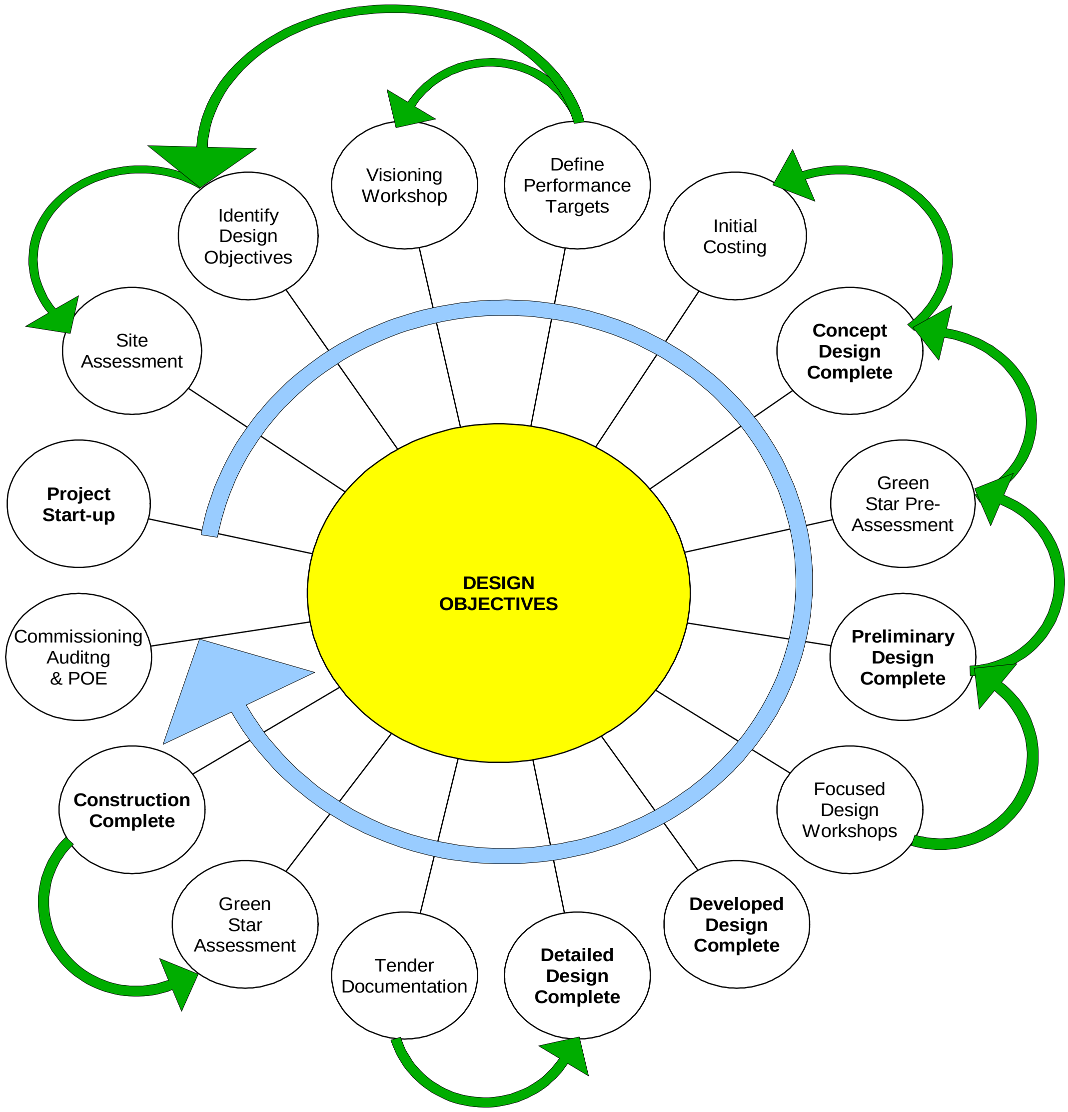


Table 1: The IWBDP versus the conventional design process

Conventional design process	IWBDP
Architect draws up initial concept design	Whole project team involved in the initial design
Only main consultants involved in the initial decisions	Whole team are involved in decisions
Time, money and energy minimised during the initial design stages	Early involvement of design team means greater costs during the initial design stages
Feedback loops during concept and tender stages only	Feedback loops throughout the process
Systems considered and designed separately	Holistic thinking – whole picture considered
Optimisation difficult due to segregation of concepts	Optimisation easily achievable
Synergies difficult to identify and employ	Synergies easily identified and encouraged
Capital cost of building considered over whole-of-life costs	Life cycle costing used to see the bigger picture
Process ends when construction is complete	Process is ongoing and includes commissioning, auditing and post-occupancy evaluation

Aitken (1998) defines the Integrated IWBDP as a method of siting, design, equipment and material selection, financing, construction, and long-term operation that takes into account the complex nature of buildings and user requirements. Busby Perkins+Will (2007) states that IWBDP is an approach to building design that seeks to achieve high performance on a wide variety of well-defined environmental and social goals, while staying within the budgetary and time constraints. The *Whole Building Design Guide* is a web-based information source (www.wbdg.org) for high-performance building design and, in particular, IWBDP. According to the *Whole Building Design Guide*, the project goals can be classified under eight design objectives (Prowler, 2007) including:

- accessibility
- aesthetic appeal
- cost-effectiveness
- function and operation
- historic preservation
- productivity
- security and safety
- sustainability.

An integrated design team must find solutions by considering all of these design objectives. There is a much higher level of interaction among the design team compared to a conventional design approach. According to Busby Perkins+Will (2007), the IWBDP relies on a multi-disciplinary and collaborative team whose members make decisions together based on a shared vision and a holistic understanding of the project. A close-working team is required and the team members must be able to view problems from several different perspectives and think outside their usual scope. The complete design team is involved with the process from the very beginning of the project. The IWBDP is based on the well-proven observation that changes and improvements in the design process are relatively easy to make at the beginning of the process, but become increasingly difficult and disruptive as the process unfolds (International Energy Agency, 2002).

The IWBDP is based on a series of workshops, starting with the initial objectives and vision for the project. It continues by developing the initial building concept through gathering together a wide range of ideas, approaches and strategies from all project team members in response to the project brief. These workshops encourage the team members to form a rapport and share knowledge from the start of the project. In particular, they reinforce the interconnectivity of the design requirements.

By the end of the concept design, the level of design is generally more detailed and thought-out than it would be following a conventional design approach. The involvement of all the design team early on means that building and system types and options are already well integrated. This also means a reasonably detailed cost-analysis can be carried out on the project fairly early on. The level of communication between design team members must be maintained for the design process to be successful. Detailed workshops require team members to visualise and evaluate their design more clearly.

During the design process it is important that all team members are kept informed of problems or changes in the project and involved in finding solutions. The team must remain engaged throughout the construction of the building. Integrated building design is an iterative process that requires regular feedback throughout the design and construction process to keep the design team informed of issues and minimise future problems.

As the design progresses, and if applicable to the building type, the NZGBC Green Star rating tools can be used towards the end of each design stage to measure a building's sustainability. If the rating tools are used to drive sustainable design this may lead to a 'points shopping' approach; however using an IWBDP encourages a wider consideration of sustainability. The IWBDP is a useful complement to the verification provided by the Green Star rating tools. Where the IWBDP focuses on the process, Green Star verifies the performance outcome.

Once the design concepts have been fully developed, the task needs to be undertaken of preparing drawings and specifications in sufficient detail to allow construction. Again this is normally done in relative isolation by the various design team members and this can lead to coordination issues. To overcome this, a common CAD-based Building Information Model (BIM), such as Autodesk Revit, should ideally be used by the design team to provide a set of coordinated 3D drawings. The BIM defines the spatial relationships between architecture, structure, services and infrastructure. The BIM can be used during the entire building life cycle, including the processes of construction and facility operation. In the future, the BIM can be extended to integrate structured text documents such as specifications and equipment data sheets.

The design team maintains its involvement throughout construction, commissioning and even post-occupancy. Commissioning is crucial in an integrated design approach as it ensures the building is being used as it was designed. An independent commissioning agent and future facilities manager should be introduced into the design team during the later stages of the design. This allows them to interact with the design team members and provide them with feedback on the design before installation. It also gives them a clear understanding of the system being installed. Feedback to the design team throughout design, construction and occupancy is encouraged to allow solutions to be formulated efficiently and to prevent the occurrence of similar problems on future projects. This method allows optimisation of the design to create a high-performance building. Generally problems are resolved earlier in the design process and a more synergistic design is produced.

It is important to carry out ongoing evaluation of the building for the IWBDP to be successful and to provide the team members with feedback. Evaluation of IWBDP buildings can be carried out using post-occupancy evaluations, energy audits and 12-month commissioning programmes. A 12-month fine-tuning programme will ensure the building is running as it should be during occupancy. It also allows for improvements in the efficiency of the mechanical and electrical systems to be made and ensures they meet the needs of the occupants. An energy audit and analysis of the running costs of the building will provide information about the energy efficiency of the building and highlight any problems. The running costs may also help to analyse the water efficiency of the building. A post-occupancy analysis will show how comfortable, healthy and happy the occupants are in the building.

The team

An integrated design process is a more involved approach than a conventional design process; it requires the involvement of the whole design team. The design team maintains a high level of communication throughout the design process and must work well together to resolve all issues and concerns on the project. According to Reed (2004) the attitude of the design team is critical and members must be able to form a collaborative framework for the project.

Busby Perkins+Will and Stantec Consulting (2007) state that the core project team members required for Integrated Whole Building Design are:

- client's or owner's representative
- project manager
- architect
- IWBDP facilitator and champion
- structural engineer
- mechanical engineer with expertise in simulation and energy analysis
- electrical engineer
- environmentally sustainable design (ESD) engineer
- civil engineer with expertise in stormwater, groundwater, rainwater and/or wastewater systems
- facilities manager or building operator (maintenance and operations)
- cost consultant (with experience in life-cycle costing)
- landscape architect
- general contractor and construction manager.

This is similar to a conventional design team but with the addition of an integrated design process facilitator and champion. The project manager or architect usually fills this role.

Environmentally sustainable design (ESD) engineers should be involved in the integrated design approach. In a conventional approach they have not traditionally been required. These engineers encourage sustainable design initiatives among the project team and are involved in managing any green strategies and accreditation for the project. They can often be involved in carrying out energy, thermal and daylighting investigations of the building using computer modelling tools.

The skills of the team

The team members must be open-minded, knowledgeable and able to analyse issues from several different perspectives. In a conventional design approach team members are usually specialists in their field. Team members are required to think outside their usual scope. Reed (2004) points out that to form the collaborative framework necessary for an integrated design approach the design team members must move from being 'experts' to 'co-learners'. No one person will have the knowledge to tackle all the issues that may occur on a project; the team members must be able to address issues together and learn from one another. Decisions and solutions are reached through cooperation and interaction between all design team members. Under a conventional design approach this would be a fragmented process involving only a few individuals.

Implementing the IWBDP

The IWBDP can be used at all stages of the design, construction and occupancy of buildings. This section identifies the steps at each stage of the design process. It is worth remembering that this is an iterative process so there are very often feedback loops within, and possibly even between, the stages. For small projects ($\leq 500m^2$) with only a few members in the design team some of the requirements of an IWBDP may be unnecessary and this is noted in the sections below. Table 2 at the end of this section compares the differences between the IWBDP for small, medium and large projects.

Project start-up

The first step in the process is developing the project brief by identifying the requirements of the building through consultation with stakeholders. This can be done through surveys or by holding a series of visioning workshops at which stakeholders can voice their opinions and have input into the design brief. The project goals at this stage do not need to be detailed, but do need to be clear enough for the project team to develop a relevant design concept and solutions.

Concept design

Process

At this stage in a conventional design process the client would normally appoint an architect to prepare an initial architectural concept. With an IWBDP this stage is much more involved and all the principal design consultants should be introduced to the project. When selecting members of the design team, it is important to consider the qualities, motivation and knowledge they will bring to the project.

A kick-off workshop should be held to introduce the project goals to the project team. Stakeholders and key staff members should also attend this meeting. The purpose of this meeting is to develop the project goals and design requirements and to encourage a relationship among the team members. The meeting should be used to encourage discussion, recognise any design conflicts and help develop the main objectives for the project, which may include:

- objectives
- assumptions and givens
- opportunities and constraints
- risks
- timeline
- budget
- spatial requirements and interrelationships
- sustainability objectives and measures
- specialist consultants required and their time of introduction to the project.

The kick-off workshop will normally require at least one day to complete.

Following the kick-off workshop, a series of design workshops need to be held by the design team to develop an initial building concept or concepts for the project. At this initial stage workshop topics should include:

- site development, and urban design and landscaping approaches
- orientation, massing and building form
- initial services distribution strategies and plant space requirements
- initial structural systems.

The initial concept design(s) should be presented to the client stakeholders and refined as necessary by further workshops.

An initial costing should be carried out at this stage. This will be required as part of the review and approval of the concept design by the client. If the project is over budget, the design team need to reassess their ideas to provide more cost-effective solutions or justify the extra expenditure to the client.

Documentation

At the end of this stage the following documents should be produced:

- initial architectural and landscaping design
- initial engineering design
- initial infrastructure design
- initial sustainability report
- initial outline specification for the project
- initial concept design budget
- outline design and construction programme.

All the above should be combined in an integrated concept design report.

Refer also to NZCIC's *Design Documentation Guidelines* for detailed deliverables (weblink included in the Further reading section).

Preliminary design

Process

Preliminary design workshops should continue to develop the detail of the initial concept design. An iterative process is required to develop the preliminary design so that it continues to meet all the project objectives. These workshops require team members to visualise and evaluate their design more clearly. More detailed workshop topics can include:

- internal space planning and circulation
- building envelope (daylighting, thermal and energy performance)
- structural systems
- lighting, acoustics and thermal comfort design
- HVAC options
- water and wastewater systems
- a fire safety strategy
- materials selection
- preliminary thermal, daylighting and energy modelling.

For small projects ($\leq 500m^2$) these design workshops may not be required and conventional design meetings can be held. These meetings may not require the presence of all the design team members; however, it is important to keep all members informed of discussions and outcomes. Meeting minutes should be circulated to all members of the design team for them to review and provide feedback if required.

Documentation

At the end of this stage the following documents should be produced:

- preliminary design report and drawings
- initial Green Star pre-evaluation, if applicable, plus a checklist for Green Star documentation responsibilities. This can be a long and involved process unless the requirements for Green Star documentation are highlighted to the project team at an early stage so that they can structure their documentation accordingly. For small projects ($\leq 500m^2$) the full Green Star process may be too extensive and can be used for design guidance only
- updated and more detailed outline specification
- detailed design and construction programme
- preliminary budget for the project

Refer also to NZCIC's *Design Documentation Guidelines* for detailed deliverables (weblink included in the Further reading section).

Developed design

Process

More detailed design workshops should be held during this stage of the design. Each one should focus on a particular part of the design. For example, the following workshops could be held:

- building envelope detailing
- final internal space planning and circulation

- air-conditioning and ventilation system integration
- structural design integration
- electrical systems integration
- hydraulic systems integration
- fire safety integration
- final materials selection
- final thermal, daylighting and energy modelling
- updated design and construction programme
- requirements and protocols for construction documentation.

It is imperative to the IWBDP that all team members are involved in the workshops so design conflicts can be identified and solved quickly. The workshops also allow pooling of knowledge and can help optimise the design.

As at the preliminary design stage, at the developed design stage small projects ($\leq 500m^2$) can follow a conventional design approach with regular design meetings. Again, it is important to keep all design team members informed of the discussions and outcomes of each meeting so they can provide feedback.

It is important that the design team are informed of the Green Star initiatives being pursued on the project at the beginning of this stage. The preliminary Green Star assessment document should highlight which credits are being pursued, and also provide an indication of how the requirements can be met.

Documentation

At the end of this stage the following documents should be produced:

- developed design report and drawings, including the following specialist reports for projects $>500m^2$:
  - energy modelling report
  - thermal comfort report
  - daylight modelling report
  - fire report
- provisional Green Star rating for buildings $>500m^2$
- final outline specification
- updated design and construction programme
- updated budget for the project.

Refer also to NZCIC's Design *Documentation Guidelines* for detailed deliverables (weblink included in the Further reading section).

Detailed design

Process

Once the design concepts have been fully developed, drawings and specifications, in sufficient detail to allow construction, need to be prepared. To assist with building integration and coordination on projects >500m^2, a common CAD-based Building Information Model (BIM) should ideally be used by the design team to provide a set of coordinated 3D models or drawings. The BIM defines the spatial relationships between architecture, structure, services and infrastructure. The BIM can be used throughout the building cycle, including during the processes of construction and facility operation. An example of such a modelling package is Autodesk Revit.

On small projects ($\leq$500m^2) a BIM may be unnecessary and a more conventional method of producing detailed design drawings and specifications can be used.

It is important to maintain team collaboration even at this stage in the design process. Workshops may no longer be required, but regular meetings should be held to keep the team members up to date on the development of the design. Only team members directly involved with the detailed design elements being discussed are required at the meeting; it is no longer necessary for the whole team to be involved.

It may be useful to involve the independent commissioning agent and future facilities manager towards the end of this stage in the design. This allows them to review the design for its ability to be commissioned, operated and maintained and gives them a good understanding of the design intent of the system.

Documentation

This is possibly the most important stage for documentation as this is when consent and tender documents are produced. It is important that the documents are coordinated between disciplines as any differences may cause confusion during the tendering and construction process. The following documents should be produced at the end of this stage:

- consent and tender drawings for each discipline
- consent and tender specifications for each discipline
- fire report:

If applicable, Green Star accreditation documents should also be collated from each discipline on completion of this stage. The documentation can then be submitted to the NZGBC who will assess it and, if successful, award a design rating for the building.

Refer also to NZCIC's *Design Documentation Guidelines* for detailed deliverables (weblink included in the Further reading section).

Tender for and engagement of contractors

Process

At this stage a contractor is engaged in the project and, if required, minor adjustments are made to the design so that it is suitable for construction. The contractor must be fully informed of the design objectives and specific project criteria that must be met. It may be useful to organise a kick-off meeting between the design team and contractor to discuss the project requirements and identify any potential issues. Contracts should include the necessary Green Star conditions, for example the inclusion of environmental management and/or waste minimisation plans, as appropriate.

A waste management company should be engaged at this stage in the process and informed of the recycling targets.

Documentation

At the end of this stage the following documentation should be produced:

- construction drawings
- construction specifications, and preliminaries and general (P&G) section
- site management plan (included in P&G)
- environmental management plan (included in P&G)
- waste minimisation plan (included in P&G)
- building consent
- project timeline, including commissioning programme for buildings >500m^2.

Refer also to NZCIC's *Design Documentation Guidelines* for detailed deliverables (weblink included in the Further reading section).

Construction and initial commissioning

Process

The involvement of the design team must be maintained throughout the construction process. Meetings should be organised with the necessary team members whenever issues arise. Site, environmental management and waste minimisation plans should be put in place, and all contractors who work on the site should be made familiar with them through suitable induction and auditing processes.

During this phase the commissioning agent should provide a commissioning plan and programme, and should also visit the construction site periodically and note any conditions that might affect system performance or operation. For small projects (≤500m^2) a commissioning agent is not required. Systems may be commissioned as part of the usual scope of the installers but an overall commissioning programme is not required for the building.

The testing and commissioning process should be carried out by the installing subcontractors to accepted codes (eg, codes and guides from Charted Institution of Building Services Engineers, Building Services Research and Information Association, and the American Society of Heating, Refrigeration and Air Conditioning Engineers). The process should also verify the proper operation of equipment and systems according to the design intent, design drawings and specifications. Point-to-point or end-to-end testing of the building management system (BMS) is highly recommended. If corrective measures are required, the commissioning agent should make sure they meet the design intent. Acceptable performance is reached when equipment or systems meet specified design parameters under full-load and part-load conditions during all modes of operation, as outlined in the commissioning plan.

A high standard of verification, completion, clearance of defects and documentation should be achieved before granting handover. After completing pre-handover commissioning, the commissioning agent should write a handover commissioning report, which includes all commissioning documentation, and submit it for review by the building owner and designers. Before handover, building operators should be trained in operating and maintaining equipment and systems. The commissioning agent should oversee the training sessions provided by the installing contractors', designers' and manufacturers' representatives.

The commissioning agent also verifies that operation and maintenance manuals include a user guide and are complete and available for use during the training sessions.

Facilities management training should be carried out as part of the initial commissioning process.

Further information on best practice commissioning, handover and ongoing operation is given in the Ministry for the Environment's report *Sustainable Government Buildings: Beyond Design* (www.mfe.govt.nz/publications/sus-dev/sustainable-government-buildings-jun07/html/index.html).

Documentation

During this stage the following documents should be produced:

- technical submissions
- shop drawings
- documentation on any adjustments made to the specification
- detailed construction and commissioning programme
- site inspection reports and defects lists
- initial commissioning report for buildings >500m^2.

It is important that records of any changes made to the design are kept for future reference and the design team are fully involved with adjustments.

At the end of this stage the following documentation should be produced:

- draft as-built drawings
- draft operations and maintenance manuals
- building user guide for buildings >500m^2.

Bake-out, handover and ongoing fine-tuning

Process

A bake-out period of two weeks should be allowed for after the building has been completed. This period can overlap with the furnishing of the building. The bake-out period is used to allow off-gassing from the finishes in the building. The bake-out should be staged within the building and furnishing can commence in areas where bake-out has been completed.

Even though the project is considered complete, some fine-tuning commissioning tasks should continue throughout the typical one-year defects and warranty period. The commissioning agent should initially return on a monthly basis for the first three months, and then quarterly through the defects and warranty period to review systems' operation and liaise with facility staff to address any performance problems. It is also helpful after six months to carry out a post-occupancy evaluation survey of the building's occupants to identify any issues with the building, and this can inform the need for any further fine-tuning.

A monthly log of energy, water and waste consumption should be kept and reconciled with the agreed performance targets. Any non-performance problems should be addressed as part of the system's fine-tuning and operational practices. Ideally, energy and water audits should be carried out six to twelve months after initial occupancy of the building. This will identify any unexpected energy or water use.

It is a good idea for the building owner to consider re-commissioning their facilities periodically to ensure that equipment performance levels continue to meet the design intent. In a sense, this means that, to maintain a high level of performance, commissioning never ends. Operation and management staff should be encouraged to audit and partially re-commission selected building systems on a regular basis, perhaps every three years, depending on building use, changes to layout equipment complexity and operating experience.

On small projects ($\leq 500m^2$) a bake-out period and auditing may be applicable; however fine-tuning may not be necessary. Regular monitoring and maintenance of building systems should be carried out by the management staff.

Documentation

During this stage the following documentation should be produced:

- practical completion certificate
- code compliance certificate
- operational environmental management plan (produced at the beginning of this stage)
- commissioning report
- final operations and maintenance manuals
- final as-built drawings
- post-occupancy evaluation report
- energy audit report
- water audit report

- end of defects inspection reports
- completion certificate.

Table 2: Comparison of the IWBDP for different project size

Process requirement	Small ($\leq 500m^2$)	Medium ($>500m^2$, $\leq 2000m^2$)	Large ($>2000m^2$)
Preliminary and developed design workshops	Workshops can be replaced by regular meetings following a conventional design approach.	Preliminary and developed design workshops should be carried out to suit the IWBDP.	May be difficult to get all the team members together for each workshop. At least one person from each discipline must be present at each of the workshops. Team members not present at the workshops must be informed of the discussions and outcomes of the workshops.
Champion/facilitator	The project manager will fill the role of the champion and facilitator.	The facilitator and champion roles may be taken up by the project manager, architect or a separate individual.	A separate individual is required for this role.
Design objectives, visioning workshop and performance targets	Performance targets can be defined alongside the design objectives either before or during the visioning workshop. These design objectives and performance targets should be considered at each project meeting.	Design objectives should be identified before the visioning workshop. Performance targets should be identified as a result of this visioning workshop.	The project may have several performance targets. The most relevant performance targets should be identified in each of the workshops.
Green Star	A full rating may be unnecessary, but the rating tool can be used as a guide in the design of the building.	A Green Star rating can be carried out if applicable.	A Green Star rating can be carried out if applicable.
Specialist modelling (energy, thermal and daylight)	Not required for projects of this size: a conventional process can be followed.	Modelling required.	Modelling required.
Building information modelling	Not required for projects of this size: a conventional process can be followed.	BIM required.	BIM required.
Commissioning, auditing and post occupancy evaluation	Commissioning not required. Auditing and post-occupancy evaluations can be carried out in-house if required.	Commissioning, auditing and post occupancy evaluation required.	Commissioning, auditing and post occupancy evaluation required.
Facilities manager	This role can be taken by any trained occupant of the building.	This role should be filled by a skilled person.	One or more skilled persons may be required.

Effective facilitation during workshops

Workshops should be managed effectively and efficiently to minimise costs and time. The following things should be considered when organising and managing a workshop.

1. **Planning**
   Each workshop should be carefully planned and the agenda circulated in advance. The agenda should include the aim of each of the items. The agenda should be followed and enough time allowed for the required outcome of each item.

2. **Reviewing**
   At the beginning of the workshop it may be useful to review the previous workshop and request feedback from the team. It is also useful to review the outcomes at the end of each workshop so the team members are clear about the decisions made during the session.

3. **Group activities**
   These will ensure interaction among the team members which is critical to the IWBDP. This can be particularly important during the visioning workshop as it will encourage the team members to form relationships.

4. **Brain-storming**
   This allows pooling of knowledge within the team and can identify possible synergy or design conflicts among the disciplines.

5. **Focus**
   The design objectives should be displayed during the workshop to keep the team focused. Regular breaks during the workshop will help maintain team members' concentration.

6. **Questioning**
   Asking the team questions will encourage thinking and could lead to innovative solutions being found.

7. **Recording**
   The outcomes of the workshops should be clearly documented for review by the design team and stakeholders. The following items should be included as a minimum in this document.

   – date and time the workshop was held, and the venue
   – name, company and role of attendees
   – brief overview of the workshop
   – agenda
   – copy of mind maps from brain-storming sessions
   – group activities and outcomes
   – agenda items completed
   – agenda items needing further attention and actions required
   – questions put to the team and answers given
   – time, date and topic of the next workshop.

Sustainability and green certification

Sustainability and IWBDP go hand in hand. Busby Perkins+Will Stantec Consulting (2007) identify sustainability as one of the design objectives that should be considered on a project. In fact, it is difficult to design a building using IWBDP without incorporating sustainable features. The reverse is also true as acknowledged by Reed (2006) who states that an integrated design process is required for the success and cost-effectiveness of a green design. In a conventional process green features are often considered after the initial design has been formed which can be disruptive to the design process and also more costly, as noted by the US Department of Energy (2001).

> *This process often includes integrating green design strategies into conventional design criteria for building form, function, performance and cost. If a building is designed as usual green technologies are usually applied as an after-thought and this results in poor integration into the overall building design objectives and the greening strategies are more expensive to implement.*

Using IWBDP on a sustainable project allow green features to be included in the very first stages of the design process. By engaging an environmentally sustainable design (ESD) engineer at the beginning of a project, green design opportunities can be identified and incorporated into the initial design. Energy, thermal and daylighting modelling should be carried out during the early stages of the process to allow optimisation of the design by determining:

- orientation and location of the building
- shape of the building
- internal layout of the building
- amount and type of glazing
- thermal performance of the building envelope
- shading features
- presence of thermal mass
- heating, cooling and ventilation system.

Most of these factors are locked down within the initial stages of the design. In a conventional design approach, modelling is either excluded completely or, if included, carried out during the developed design stage and so provides limited benefit to the project other than design verification. Energy and thermal modelling can be used to make the building more comfortable for the occupants, improve energy efficiency and reduce HVAC system requirements or improve passive heating, cooling and ventilation design. Daylighting analysis can also help to improve the amount of natural light available to internal spaces and reduce the requirement for electrical lighting. These investigations are crucial to the design of a green building and usually also play a part in the green rating and certification of the design. Currently, the only official green certification scheme available in New Zealand is the NZGBC Green Star for office design. This rating tool assesses the sustainability of the design based on these eight criteria:

- management
- indoor environmental quality
- energy

- transport
- water
- materials
- land use and ecology
- emissions.

The assessment of these criteria is combined to produce one score which can then be compared to:

- 4 Star, which signifies ‘Best Practise’
- 5 Star, which signifies ‘New Zealand Excellence’
- 6 Star, which signifies ‘World Leader’.

The benefits

IWBDP produces higher-performance buildings. They tend to be more energy efficient, have a better internal environment, are more comfortable and have less operating and maintenance issues and costs than other buildings. They are also more in tune with the environment.

Buildings designed through IWBDP have a better indoor environmental quality (IEQ). Recent studies have shown that occupants who work in buildings with good IEQ are healthier, happier and more productive. Fisk (2002) states in his study that speed or accuracy of workers can change by 2 to 20 percent for various office tasks due to a change in temperature of just a few degrees. Staff may find it easier to concentrate and are less likely to take sick days. Companies may find their popularity as an employer increases and staff turnover is reduced. All these things can improve the marketability of these buildings and they can be sold or rented out for higher amounts than conventionally designed buildings.

There are benefits to the actual IWBDP itself as it stimulates a team spirit among designers and the client, since everyone plays a vital role in the project. Designers are encouraged to be more innovative and expressive with their ideas and solutions, which makes IWBDP projects more interesting to work on. The IWBDP requires feedback and the project team learn from their mistakes as well as their achievements. Table 3 gives the benefits of the IWBDP.

Table 3: The benefits of IWBDP

IWBDP principle	Benefits
Whole team involved from the beginning of the design process	• Potentially fewer issues later in the project • Systems are more integrated • Synergy is recognised early and easily employed • Optimum solutions found • Conflicts between disciplines recognised early
Continuing team collaboration and sharing of knowledge	• Team learns from one another • Solutions are fully integrated
Project goals clearly identified	• Design is focused • Common understanding among team
Feedback loops throughout the process and ongoing evaluation	• Problems identified early • Ongoing learning for designers • Mistakes avoided in the future
Holistic thinking	• Integrated solutions found • Optimisation of design easily achievable • Sustainable features easy and cost-effective to incorporate
Life-cycle costing	• Construction costs balance with operational costs
Commissioning	• Ensures building systems are running correctly

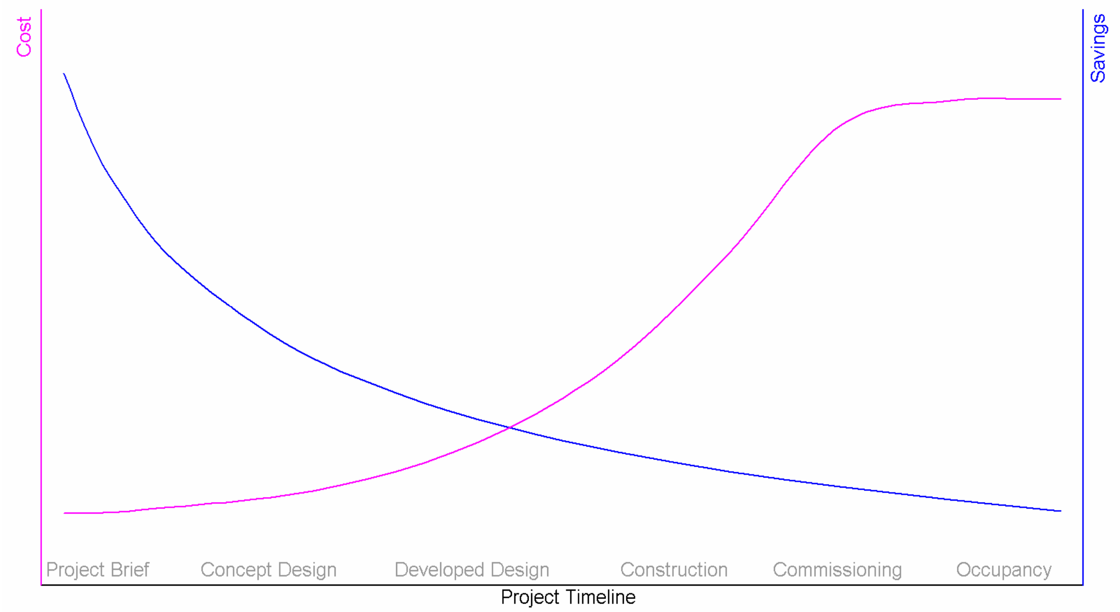
The costs

Design and construction costs

Generally, buildings designed using IWBDP are not necessarily more expensive and can even be more cost-effective than conventionally designed buildings. The Landcare Research Building in Tamaki (see New Zealand case studies section below) was designed and built with no extra costs compared to a conventional process (Landcare Research, 2008). The Mathematics, Statistics and Computer Sciences Building at the University of Canterbury was designed and built for less than a similar conventional building on the campus.

Using IWBDP can also make the inclusion of sustainable features in a building design more cost-effective. As mentioned previously, these features are usually thought of after the initial design has been drawn up, making them more difficult and more expensive to include, as illustrated in Figure 3.

Figure 3: Costs of changes and potential savings of synergy in the design



The design team required for an IWBDP project needs a broad range of expertise which, according to Cole et al (2007), can help avoid costs attributed to using a less experienced design team and their consequent learning curve. Cole et al (2007) also recognise that the additional costs of hiring extra consultants at critical parts of the process is offset by fewer errors, innovative concepts and solutions, and significant reduction in capital and operational costs. The cash flow over the design stages is different between the IWBDP and a conventional design approach. The design team's involvement earlier in the design process means costs are higher at the beginning of the project. This approach prevents problems occurring further in the design process and can reduce costs at later stages.

Using IWBDP also requires a greater level of interaction between team members throughout the design process, and poor management can increase project costs. Time during workshops and meetings should be used efficiently and effectively. This is particularly important when there are several members in a design team as the cost of having everyone attend the meetings can be quite high. Communication should be clear to avoid wasting time and money.

Running costs and payback periods

Buildings designed using an IWBDP usually include sustainable design features that provide good energy and water efficiencies. The *Value Case for Sustainable Building* (Ministry for the Environment, 2006) found that although initial capital costs increased by 2 to 6 percent, they are likely to be repaid five to six times over a 20-year period by operating cost savings. IWBDP buildings also tend to be higher-performance buildings which have good marketability. This means they can bring in higher rents for owners. They also tend to be healthier, more pleasant buildings to work in so staff are easier to retain and are less likely to take sick days, meaning higher productivity for companies. Companies occupying higher-performance buildings have recorded an increase of 5 to 15 percent in staff satisfaction and productivity levels, based on post-occupancy evaluation studies.

International case studies

City of White Rock Operations Building, Canada

The City of White Rock Operations Building achieved a gold Leadership in Energy and Environmental Design (LEED) certification for its green design. It has a green roof which helps prevent heat gain to the internal environment. It is also designed to allow natural ventilation throughout the building. The heating and cooling of the building is assisted by a heat pump system using stormwater collected from the city streets. A solar thermal system provides hot water.

Dockside Green, Vancouver, Canada

Dockside Green is a 15-acre mixed-use site in Canada, designed holistically to function as a total environmental system. Phase One of the site has been completed and has achieved platinum LEED certification. The same level of certification is being targeted for the rest of the site on completion. The site has been designed to be greenhouse gas emission neutral with the incorporation of an integrated energy system. This system may even produce excess energy which can be sold back to the grid. The system includes a biomass plant for heating and hot water. Other sustainable features include energy efficiency features, on-site waste water treatment, green roofs and a car co-op.

Liu Centre, Vancouver, Canada

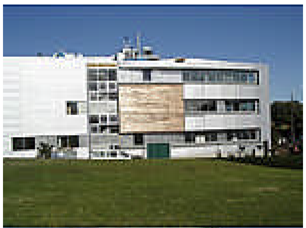
The Liu Centre for the Study of Global Issues in Vancouver was designed by Stantec Architecture and completed in 2000. Project goals for this project were identified in day-long workshops that were attended by stakeholders and project team members. The team was expected to meet a rigorous mandate with 60 sustainable project goals identified. Several sustainable features were included in the building such as:

- natural ventilation
- thermal mass
- energy efficiency
- water efficiency
- heating of hot water using waste heat
- use of salvaged materials
- efficient use of building materials.

The building was designed and constructed to integrate with the natural environment. Its positioning and orientation were chosen to optimise daylighting and solar gain, given the shading by the surrounding forest. Computer modelling was used as an aid to the design of the building form to ensure effective air movement for natural ventilation.

New Zealand Case Studies

Landcare Research Building, Tamaki

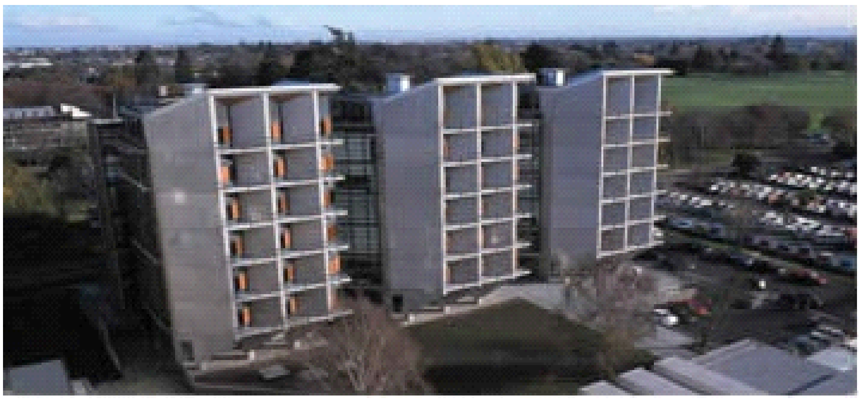


The Landcare Research Building in Tamaki is a sustainable development designed by Chow-Hill architects and Connell Mott MacDonald. Visioning and sustainability workshops were held with a large range of internal and external stakeholders to frame the sustainability objectives and to identify any barriers to the project. A Natural Step Workshop was also held to reinforce the importance of sustainability in the design. The design was then developed with the needs of those using the building in mind, and synergy was identified between these, the environment and economics. The building is both energy and water efficient. The mechanical and electrical systems have been integrated so they function off each other where possible. A contractor was brought into the team at an early stage of the design.
The construction costs were estimated to be the same as if the building was designed using a conventional approach. The building is expected to save approximately $70,000 a year in energy bills, which is a 60 to 70 percent reduction in energy consumption (Landcare Research, 2008).

The building achieves a 60 percent rating under the National Australian Built Environment Rating System NABERS (Landcare Research, 2008). This government environmental performance tool rates the energy and water use within a building. Research into improving the environmental sustainability of this building is ongoing.

Maths, Statistics and Computer Science Building, University of Canterbury

The Maths, Statistics and Computer Sciences Building at the University of Canterbury was designed to include passive heating, cooling and ventilation features to help it achieve the required energy target that was set at the beginning of the project. Thermal and computational fluid dynamics (CFD) modelling was used to assess the comfort levels of spaces in the building. Integrated features of the building perform multiple functions where possible to minimise materials use and recognise the interconnectedness of some of the design principles.



Stakeholders were involved in identifying the design objectives and reviewing the developing design. Innovative design concepts were used in parallel with traditional methods to achieve optimum solutions. A building user manual was created to inform occupants of the heating and ventilation systems installed in the building. Ongoing evaluation was used to assess the building's performance. A post-occupancy evaluation was carried out by Victoria University of Wellington which showed the building came within the top five percentile of buildings tested by the building use studies (BUS) method, indicating a high level of satisfaction.

The cost of the project was calculated at $\$2,000/m^2$ which is 15 percent below the estimated conventional building cost of $\$2,300/m^2$ (Ministry for the Environment, 2007). An energy audit showed the annual energy consumption to be $140kWh/m^2$ which is below the standard annual energy consumption of $185kWh/m^2$ for a building of this size (Ministry for the Environment, 2007).

Conservation House, Department of Conservation, Wellington

The design brief for Conservation House was for a high-performance building that included energy efficient and environmentally sustainable strategies. Active chilled beams, natural ventilation, a high-performance double skin facade and high-performance lighting provide energy-efficient solutions within the building. The Department of Conservation staff were surveyed and their needs were included in the design brief. The Australian Green Star rating tool was used as a guide for sustainability in the design.

Inland Revenue Greater Wellington Property Project

When the Inland Revenue was seeking new leased accommodation from building owners in Wellington, it used an innovative and collaborative procurement process. This included developing a non-prescriptive accommodation brief with a series of defining objectives and performance indicators. The brief was subject to extensive consultation with Inland Revenue stakeholders. Post-occupancy evaluation and building condition surveys were also undertaken on existing Inland Revenue facilities to further inform the process.

A collaborative design approach was then used with a number of shortlisted building owners by using their expertise and that of Inland Revenue's project teams to maximise the opportunity of creating an innovative solution. The purpose of the approach was to ensure that the specific needs of Inland Revenue were incorporated into the preliminary designs for their accommodation solution.

The selection process began with an initial registration of interest followed by a stage one request for proposals to obtain a shortlist of prospective building owners who demonstrated that they were able to work in a collaborative manner and had the potential to deliver an accommodation solution that fully met the needs of Inland Revenue.

The stage two request for proposals was a 10-week process which included pre-scheduled meetings for building owner and Inland Revenue project teams to discuss building design, commercial terms and building operation to provide an environment that supported Inland Revenue's business. The workshop meetings required building owners' teams to present the various elements of their proposals and to submit questions which were answered by the Inland Revenue project team. Inland Revenue's project team provided guidance and feedback to building owners and their project teams.

Selection of the preferred building owner was on the basis of final written submissions and presentations and a weighted attributes analysis which included a sophisticated whole-of-life financial analysis considering all hard and soft costs.

Following the selection of a building owner to provide the accommodation solution, Inland Revenue continued the same collaborative approach until the accommodation solution design was completed.

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